The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 20. MARCH, 1918. No. 195.

PUBLISHED THE FIRST WEEK IN EACH MONTH

Subscription Terms: 7s. 6d. per annum, post free.

To place the "**Journal**" within the reach of working Moulders and Pattern-makers, the Proprietors will accept subscriptions, not less than three in number from one shop, at the reduced rate of 5s. per annum, such order to be countersigned by the superintendent or foreman.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
165, Strand, London, W.C.

OWING TO THE REDUCTIONS IMPOSED BY THE GOVERNMENT ON PAPER SUPPLIES, THE PROPRIETORS ARE COMPELLED TO PUBLISH "THE FOUNDRY TRADE JOURNAL" ON A THIN PAPER DURING THE CONTINUANCE OF THE RESTRICTIONS.

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Sheffield and District: J. Dickinson, 157, Abbeyfield Road, Pitsmoor, Sheffield.
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London: Jas. Gaunt, 29, Chandos Road, East Finchley, N.2.
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Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.
East Midlands: H. Bunting, 17, Marcus Street, Derby.

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British Foundrymen's Association: East Midlands Branch.—"Some Notes on Moulding Sands and Facings," by J. Shaw.

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British Foundrymen's Association: Newcastle Branch.—"Notes on Cast Iron Test Bars," by H. J. Young.

NOTES AND COMMENTS.

Utilisation of Technical Libraries.

Those of our readers who have followed the co-operative movement among technical and scientific institutions in Germany will remember that Dr. Springorum, in the course of his address at the Düsseldorf meeting of the Association of German Iron and Steel Makers in March last year, emphasised the fact that the present war has intensified the need, already felt before, for a closer co-operation of the German technical societies and that preliminary steps in this direction have led to a combination of some societies into a German Union of Technical Scientific Associations. The Union leaves to its individual units and members complete liberty in their own special branch, but endeavours to ensure active co-operation and joint action of all the associations (numbering now thirteen) on all important questions.

In our own country, it will further be remembered, Sir Robert Hadfield submitted about a year ago a scheme of organisation to the Iron and Steel Institute which has been largely adopted, and he has also submitted certain suggestions for the consideration of the Board of Scientific Societies formed by the Royal Society. Sir Robert has for a long time held the view that in this country much valuable work of our scientific and technical societies is lost or wasted, or at least not rendered so useful as it might be, for want of proper collaboration, co-ordination and organisation amongst the societies concerned, resulting among other things in far too much overlapping.

One of Sir Robert Hadfield's suggestions touches what one may term the pooling of the technical and scientific societies' libraries, especially their collections of periodicals; also their housing under the same roof, where the different units could hold their meetings and gather together their books and periodicals in a common library open to every member of the associated societies. In the United States the four leading societies of engineers—the Mining Engineers, Mechanical Engineers, Electrical Engineers and Civil Engineers—meet in the same palatial home, the Engineering Societies' Building in New York, with a library now comprising some 150,000 volumes, and covering the requirements of not only the four leading institutes, but also of some two dozen smaller societies.

It is the opinion of many that the Germans, and in a lesser degree the Americans, are some years ahead of us in this respect, especially in the matter of technical education, and that one of the first steps to be taken will be to secure a large reserve of technically-trained men in industry, who will be able to appreciate the advantages of a technical library and of technical research. Our experience is that at the present moment many of the subordinate officials do not even keep abreast of the current literature, and are consequently not in a position to discuss or to offer suggestions on subjects intimately con-

nected with, and affecting the progress of, their calling. The men who can discuss with profit to their fellow-workers scientific and technical problems in the iron and steel industry, for instance, to-day are very few, whereas they should be numbered by hundreds. Once we have this body of trained technical men, advancement on similar lines to that which obtains in the United States and Germany will follow naturally.

At the same time the geographical difficulty must not be lost sight of. A central library, such as the one proposed by Sir Robert Hadfield, would, of course, be of great service to people who do not live too far away from such fountainhead of technical knowledge, but some provision will have to be made for people who do not live in its immediate vicinity. For this purpose local facilities will have to be provided in the shape of reading rooms, stocked with technical literature and established in busy centres, which the larger industrial establishments could assist by grants in money, books and periodicals. These centres could then exchange books and periodicals at fixed intervals.

The Germans have carried the practice of interchanging books to great perfection. A student at, say, the University of Berlin finds a reference to a book or periodical which he would like to consult in the original. He applies to the librarian of his own university, and if this official cannot produce it from his own stock he can, as a rule, in a few minutes ascertain the whereabouts of a copy, and will apply for the loan of it from some other university or Royal or Grand-ducal library, as the case may be, which will lend the book or periodical, or even a precious MS., to the applicant for a certain period without further ado, and as a matter of ordinary routine. In respect of research work, therefore, a German student is in a much more favourable position than a student at, say, Sheffield, who has to wait until his next trip takes him up to London. At some of the large industrial establishments in Germany, as, e.g., at Krupp's, quite a respectable collection of current technical periodicals is lying on the tables of the reading room in the employees' casino. If the proposed Central Library in London could be combined with a Library Service Bureau to assist members as in New York, literary research work would be eased considerably and industry would reap the full benefit.

The Scrap Question.

For some months past an effort has been made by the Ministry of Munitions to secure a more plentiful supply of iron and steel scrap. Much of the more readily marketable scrap has already been melted, but there are still vast reserves in the country. Much of this is so widely scattered and in such small quantities that at the moment it hardly pays for collection; but there is another large reserve, and that is old plant and machinery lying in the yards of all classes of industrial establishments—mines, engineering works, steel works, brickyards, etc. Some of this scrap forms part of the stock-in-trade of the manufacturer. It may consist of discarded machinery, or old spares which have never been used, and which were intended for plant now obsolete perhaps. This material has usually a value greater than its value as scrap metal. The position, however, is that up to the present the owner of such old machines, engines, boilers, etc., has only been able to realise scrap metal value for them. Moreover, the sale of scrap, whether in the shape of machinery or iron and steel, has been held to be a charge against revenue, whereas it should properly come under the head of demolition of plant, and be written off capital values. The Inland Revenue have hitherto refused to allow this, with the result that it has naturally been difficult to get manufacturers to sell, because in so doing they would to some extent be disposing of their assets.

In connection with this question it is interesting to recall a Paper presented at the recent general meeting of the American Iron and Steel Institute, by Mr. W. Vernon Phillips. In the course of his remarks the author said that there is an erroneous impression regarding the source of iron and steel scrap, and it is likely that not half a dozen men in the industry would figure the same way, but it is the opinion of authoritative judges that 25 per cent. of all the iron and steel scrap is produced by the railroads, 40 per cent. by the industrial plants in the form of new crop ends, structural crops, ship plate, stampings, turnings and borings; the other 35 per cent. is shipped by scrap yards, of which probably one-half consists of railroad and industrial scrap sent to the yards to be sheared and prepared, leaving 15 per cent. to 20 per cent. which is collected by the junk dealers. But while the collection of old agricultural, house and city scrap represents a comparatively small portion of the entire production, it is at the present time a most important part, as *that* is the only source which can be increased. The railroads are producing less, due to labour conditions; industrial plants can only produce scrap in proportion to the amount of steel they receive, while all scrap due to replacements is smaller in volume, owing to the difficulty in replacing machinery or equipment of any kind.

Industrial Research.

A step in the development of industrial research work is the formation in Glasgow of a Scottish Engineering, Shipbuilding, and Metallurgical Research Association. The question has been under consideration for some time and has engaged the attention of the Institution of Engineers and Shipbuilders in Scotland and the West of Scotland Iron and Steel Institute. As a result of representations received from the Advisory Council of the Committee of the Privy Council for Scientific and Industrial Research a joint committee of the two bodies prepared a draft memorandum outlining the objects of the Association. A meeting, which approved of the scheme, was held in Glasgow recently, Mr. A. Cleghorn, president of the Institution of Engineers and Shipbuilders in Scotland, presiding. Mr. H. Beard, president of the West of Scotland Iron and Steel Institute, said that that body had given the matter careful consideration, and were happy to join in the proposals made. He urged that they should take care to secure some portion of the very large sum set aside by the Government before it was frittered away in directions which perhaps might not be so useful. Mr. R. Robertson dealt with the position of the Advisory Council, the principal purpose for which it was formed being, he said, that of co-operation. A committee was afterwards appointed, including the presidents of the various industrial associations in the district, and members of the Iron and Steel Institute and the Institution of Engineers and Shipbuilders.

Extensions to the Vulcan Ironworks, Bradford.

It is about three years now since Messrs. Thwaites Bros., Ltd., commenced to manufacture steel wheels for motor-transport wagons, at this time the wheels being put through as part of the general output of the foundry and machine

FIG. 1.—VULCAN IRONWORKS: GENERAL VIEW OF WHEEL SHOP.

shops. It soon became apparent, however, that considerable additions would have to be made to the plant in order to cope with the rapidly increasing demand for such wheels. It was impossible to provide the necessary space for the additional plant in the existing shops, and the management therefore decided to extend the foundry and to devote this extension to casting wheels and their component parts, while at the same time erecting blocks of buildings for machining the wheels, etc. These extensions have now been completed, so that the wheel department is, to all intents and purposes, a self-contained works. Some few months ago we published an article on the general extension of the foundry and its equipment; recently, however, a third electric furnace has been put down, each of the furnaces being 600 k.v.a. capacity. Another interesting addition to the foundry equipment is the sand-drying furnace. Dealing with sand as brought in, it is a difficult matter to obtain anything like uniformity in the moisture content, but by thoroughly drying the whole of the sand and then adding a given quantity of water, absolute uniformity is of course a simple matter.

FIG. 2.—VULCAN IRONWORKS: VIEW IN NEW CORE SHOP.

The sand-drying plant is really an adaptation of the ore-drying plant of which Messrs. Thwaites make a speciality, the essential difference being

that whilst with the ore-drying plant the furnace is placed at one end of the oven and the products of combustion pass together with the ore completely through the oven, with the sand plant the oven is built in the form of a circular tunnel passing through a brick furnace, so that the products of combustion do not come in contact with the material being dried.

The dryer comprises a circular tube 20 ft. long by 3 ft. in diameter, provided with a series of longitudinal strips, which serve to pick up and turn over the sand as the oven revolves. The oven is built into the furnace with a downward incline towards the delivery end, and is slowly revolved through gearing at the feed end from a motor-driven shaft. The capacity of the oven is 25 tons per day, with a total fuel consumption of approximately 10 cwts. of coke.

The paraffin burners for skin drying have been superseded by gas-burners working under pressure. These have proved thoroughly sound in operation, and, a matter of considerable importance in these times, have led to a large saving of paraffin.

The finishing machine shop contains upwards of 60 capstan lathes and also a number of vertical turning and boring machines. One end of the shop is divided off as a tool room, and a side building, which is provided with a wagonway for loading up, serves as a finished stores. Shutes are placed at intervals along the shop floor for the turnings and swarf, delivering into bucket hoppers in the basement. These hoppers are wheeled to the mill in which the turnings are broken down. The crushed material is then loaded into buckets, which are conveyed by an aerial ropeway (Ropeways, Limited) for a distance of 150 yards across the yard to an automatic tipping tower above the foundry. The shute from this tower delivers the crushed material into buckets on the floor of the basement beneath the furnaces, from which they are raised by crane to the charging platforms. The ropeway is driven by a 5-h.p. motor.

In connection with the machine shops are works, offices, ambulance room, mess room, etc.

New Rules for Tin Dealings.

The official rules for trading in tin on the London Metal Exchange are as follows :—

(1) Importers and dealers may only sell in the United Kingdom against purchases in the East and elsewhere already shipped or to be shipped to the United Kingdom. They may only buy in the United Kingdom for account of or against sales made to consumers or dealers in the United Kingdom or against sales made for shipment from the United Kingdom or against tin lost in transit to the United Kingdom.

(2) Smelters may only sell in the United Kingdom against purchases of ore or against English tin produced or in course of production. They may only buy in the United Kingdom against actual sales of English tin not already covered by ore or tin produced or in course of production.

(3) Without written permission from the Committee brokers may only execute orders for account of importers, dealers, smelters, or consumers who have given them a written undertaking to abide by these regulations. Under no circumstances may brokers, dealers, importers, or smelters execute orders for shipment from the United Kingdom unless there is reasonable prospect of export licence being obtainable, and the weekly returns which in future are to be made to the Metal Exchange authorities must state the total quantities sold for export from the United Kingdom for which licences to export have not been received and also the destination.

(4) Consumers may only buy for their own requirements, and may not resell without written permission from the Committee.

(5) Notwithstanding the above restrictions importers, smelters, and dealers are to be allowed to replace sales or purchases in other positions in the United Kingdom and for the purposes of normal trading to carry stock or to go short to a maximum quantity sanctioned by the Committee in the case of each individual firm, but in no case shall this quantity exceed 100 tons.

The method of arriving at the balance of any firm's position has (according to "The Times") been clearly defined; also the style in which the weekly return to the Metal Exchange must be drawn up. The first return had to be made up to Saturday, February 23, and to be delivered to the Secretary by Tuesday, February 26.

ELECTRIC FURNACES IN NORWAY. — Mr. Haakon Styri presented an interesting Paper at the recent annual meeting of the American Electrochemical Society on the present state of electric furnace working in smelting iron ores and making steel in his country of origin, Norway. According to the author, who is metallurgist to the Hussey-Binns Steel Company, at Charlevoi, Pennsylvania, the Jössingfjord Manufacturing Company built an induction furnace of the Hiorth type, in 1909, and shortly after the Hardanger Jernverk, at Tysaa, adopted there the Electrometall furnace, with modifications in design, but the operation was not successful. Before the Hardanger Jernverk started work in 1911, experiments were made at Notodden, with the 500-kw. furnace of the Bie-Lorentzen and Tinfos Paper-Fabric. After wholly successful trials with coke, the Tinfos Jernverk was formed, which built three 1,200-kw. furnaces of the single-phase type, with bottom electrode, rectangular chamber, and two charging stacks. Work started here in 1912. In the beginning many difficulties had to be overcome, but now the furnaces operate very regularly. White and grey pig-iron of high quality can be produced at will, competing with charcoal iron. It is of interest to note that most of the manganese in the ore is reduced. From data published, the energy consumed per ton is 2,700 kw.-hrs. for white pig, and 3,000 kw.-hrs. for grey pig, with 44 per cent. iron in the ore. A Tinfos furnace has also been built at Ulefos, using phosphoric ore. Foundry iron is produced, which is remelted in a Rennerfelt furnace and then run into stove castings. The most important company in Norway melting and refining scrap for tool steel and steel castings is the Stavanger-Staalverk, at Stavanger, which started in 1913. The scrap is melted in an open-hearth furnace and refined in a 5-ton Roechling-Rodenhauser single-phase induction furnace. A number of other small electric-furnace installations have been formed on account of the war-time profits in steel castings and special steels. Thus a small Roechling-Rodenhauser furnace at Eureka, Christiania, makes acid-resisting steel; at Hamar, Hougsund, and Drammen, cast steel is made in Rennerfelt furnaces, and at Kongsberg and Naes tool steel is made in the same type of furnace. Most of the electric furnaces built in Norway are of the Rennerfelt type, and the furnace (an arc furnace) is very well adapted to the remelting of scrap for cast steel in small quantities. In late years in Norway there has been a great desire to get iron and steel works which could produce shapes, plates, &c., but the present soaring prices of all new construction has put a stop to further important development. Government interest in the development has been created, and as a strictly war measure, a bonus on the production has been granted to the Kristiania Spikerverk for a second open-hearth furnace and a small bar mill and the extra funds necessary to build a new cupola and Tropenas converter have been voted to the Strömmen Staalverk. Conditions are not promising for the production of steel on a larger scale in Norway.

Brass Rolling-Mill Alloys.*

By R. A. Wood.

By far the greater proportion of the brass rolling mill alloys are made up from straight copper and zinc mixtures, and these same mixtures, with the addition of a small quantity of another metal or metals, constitute a majority of the brass rolling mill alloys. The metals employed for making up the alloy must be of good quality and practically free from impurities. Great care must be taken to avoid even traces of antimony or bismuth, for if these metals are present in the alloy, even in a fraction of a per cent., they will have a tendency to cause it to break up during fabrication; also, the chances of the metal fire-cracking during the annealing operation are increased, and if by any chance the metal should successfully pass the fabricating and annealing operations, season cracks will most likely make their appearance, sooner or later, in the finished product. Copper and its alloys readily absorb sulphur, if given an opportunity to do so, and this has a tendency to cause the metal to become spongy and porous in spots; if sulphur is present in any considerable quantity it will cause the metal to become brittle and to break up during fabrication. The absorption of the sulphur takes place during the melting operation, and is caused by the metal not being properly protected from the gases of combustion. Care should be taken to select a fuel as free from sulphur as circumstances will permit. **Charcoal**, when broken up into fine pieces, has the property of absorbing sulphurous gases and care should be exercised to see that the metal is protected with a good covering of charcoal during the melting operation.

Metals containing arsenic to any considerable amount should be avoided, for the influence of this metal upon the alloy is very similar to that of both bismuth and antimony.

The quality as well as the quantity of the zinc used for making up the mixture has a bearing upon the physical characteristics of the alloy, and care should be taken to select a grade of zinc suitable for the uses to which each particular alloy is to be applied.

Only the best grades of copper are safe to use in making up the alloy, and it is well to have the copper cut up into pieces as small as practicable in order that it will not protrude over the top of the crucible and be exposed to the gases of combustion.

Copper-Zinc Alloys.

A mixture made up of approximately 50 parts of copper and 50 parts of zinc represents the highest contents of zinc the alloy may contain and still be "workable." It is possible to roll an alloy of this nature into a sheet or draw it into a wire, but the operations are so tedious as to limit their being carried out on a commercial basis. This alloy is commercially used as either "fine" or "long-grain" spelter-solder and is used for brazing purposes. The grain of the solder is controlled by the heat at which the metal is poured. Cold pouring and rapidly cooling will produce a fine-grain solder, whereas hot pouring and slow cooling produces the long "needle-like" grain. The solder is broken up by means of a stamping or grinding operation, at what is called a "black" heat; that is the colour the metal assumes under the influence of heat, as it turns from a yellow to a dark-red colour. The soldering operation is usually carried out in conjunction with a flux having calcined-borax for a base.

Alloys made from mixtures of from 57 to 63 parts of copper and the balance zinc are used in the extruding process of making rods, tubes and shapes of varying cross-sectional area. The extruding process is carried out hot, but the work is, as a rule, given one or two cold finishing operations on a draw-bench. Mixtures of this nature may also be rolled hot and are representative of the commercially hot-worked alloys. These mixtures are known under various trades names, such as Muntz metal, yellow metal, yellow sheathing, condenser tubing, extruded metal, etc.

The grade of metal to be used for making the "hot working" alloys must be carefully selected and the casting operation carefully carried out. This does not mean that it is always necessary to buy new material, as there are mills which make a practice of buying up scrap and melting it in a reverberatory furnace, after which it is cast into bars which may be either rolled hot or extruded; but the mills which are doing this successfully have a highly specialised melting crew, who can tell from experience and certain physical tests when they have the metal in the proper condition for casting the bars.

A mixture made up from 60 parts of copper and 40 parts of zinc is about as cheap an alloy as can be successfully worked cold, although there are mixtures composed of from 57 to 59 parts of copper and 43 to 41 parts of zinc which may be rolled into sheets or drawn into wire.

The successful working of the foregoing mixtures depends primarily upon the skill with which the casting operation is carried out. Alloys containing a high percentage of zinc do not as a rule polish up nicely, as the surface of the metal is more or less likely to have a pitted and streaky appearance.

The mixtures given below represent some of the alloys used in actual practice. These proportions do not represent the analyses of the alloys, but are the weights used by the casters in making up their mixtures :—

Trade name of mixture.	Copper.	Zinc.
Brazing or hard solder	50	50
Extrusion brass	55	45
Extrusion brass soldering or spelter wire	57	43
Soldering or spelter wire (worked cold)	59	41
Muntz metal. Yellow metal	60	40
Check brass (baggage checks, etc.)	62	38
Cutlery brass (knife linings)	63	37
Hoop brass (pail hoops, etc.)	64	36
Common brass. Market brass. Pin wire	65	35
Drawing brass. Dripping brass	66	34
Shrapnel brass	67	33
Clock case metal. Extra spinning brass	68	32
Cartridge brass	70	30
Spring brass (extra quality)	72	28
Brazed brass tubing (extra quality)	75	25
Common low brass	80	20
Good low brass	83	17
Best low brass	85	15
Medal metal	86	14
Bronze (regular)	88	12
Rich or best bronze. Goldine	90	10
Gilding	93	7
Percussion cap gilding	95	5
Primer cap gilding. Copper stripe	97	3
Copper (brass mill)	99	1

* Abstract of Paper read before the American Institute of Metals.

Annealing of Copper Alloys.

Extreme care must be taken in the annealing of these alloys. Those high in zinc are apt to "run" in places if slightly overheated. The alloys are very soft and pliable at a red heat, but upon cooling they become somewhat hard and stringy. If they are plunged into a tank of water immediately after being removed from the annealing furnace they will remain much softer than if allowed to cool gradually. This is more or less a risky procedure, for if the plunging temperature is not just about right some of the metal will split and crack. These cracks are known as "water cracks," and they must not be confused with "fire cracks," which they closely resemble. If the hot metal is cooled off by means of a stream of water, such as is thrown from a hose pipe, it will cause "water cracks," but if the cooling operation is carried out by means of a fine overhead spray of water this difficulty will be practically obviated.

Fire cracks may be said to be of a mechanical nature and are caused by an unequal stress within the metal itself; as the metal is heated in the annealing furnace this internal stress causes an unequal expansion of the metal to take place which has a tendency to cause it to pull apart. A metal which has been thoroughly worked seldom fire cracks.

Season cracks may be said to correspond to delayed fire cracks, and are caused by the gradual equalisation of strains within the metal. However, overworked metals will, in some instances, develop season cracks. The grade of metals used in the alloy, the melting practice and the mechanical operations applied to the metal all, in a greater or lesser degree, contribute to the cause of season cracking. The straight copper-zinc alloys containing more than 65 per cent. of copper, if properly worked, seldom cause trouble due to "water," "fire," or "season" cracking.

Metals which have been properly cast and rolled or drawn should, if rightly annealed, have a good surface and a close grain, and it may be safely assumed that, in almost every instance when a porous, open or coarse-grained metal is encountered the trouble is in the annealing operation.

Alloys containing 80 per cent. or more of copper often cause trouble due to the presence of small pinholes and blisters. The imperfections are at times as fine as pin points, and at others show pronounced blisters and spills or streaks upon the surface of the metal. These defects invariably are directly traceable to faulty workmanship in the casting shop.

For making alloys high in copper, such as the rich bronze and gilding mixtures, some manufactures, have within the past few years installed large reverberatory furnaces suitable for melting copper in large quantities. The mixture is then made up by placing the required quantity of zinc in a previously heated crucible and then adding the molten copper to it, after which the mixture is stirred and poured into the moulds in the usual manner.

Leaded Copper Alloys.

The straight copper-zinc alloys all possess the common characterstic of being of a tough and tenacious nature, and will be found difficult to work under a tool for milling, turning, drilling or engraving purposes. In order to impart the free working qualities a certain amount of lead is added to the mixture.

Alloys containing lead will not stand as great a reduction without cracking as will the alloys free from lead. Alloys containing lead do not have as close a grain as those which are free from it, consequently they do not polish up as nicely. The leaded mixtures are as a rule poured at a lower temperature, and care must be taken not to overheat them during the melting operation, as this is liable to cause very fine black specks to appear throughout the metal.

The following are some of the leaded alloys:—

Trade name.	Copper.	Zinc.	Lead.
Extruded rod (free turning)	56.00	42.00	2.00
" shapes	56.00	40.00	4.00
Collett brass (clock work)	58.00	39.50	2.50
" " "	60.00	37.00	3.00
Clock brass (wheels and frames) ..	62.00	36.50	1.50
" " " " ..	64.50	35.50	1.75
Brass rods (free turning)	63.00	35.00	2.00
" " "	64.00	35.00	1.50
Die sinkers' and engravers' brass ..	65.00	33.00	2.00
" " " ..	66.00	33.00	3.00
Block brass	67.00	33.00	0.75
Watch brass	68.00	32.00	2.00
Balance wheels (clocks)	70.00	30.00	2.00
Brazed tubing (for threading)	72.00	28.00	1.00
" " " ..	75.00	25.00	2.00
Screen plates	76.00	22.00	2.00
Low brass (turning rod)	80.00	20.00	1.00
" " (free cutting)	83.50	15.50	1.50
" " (kick plates)	85.00	15.00	1.00
Extruding bronze	87.50	10.00	2.50
Bronze leaded (engravers)	88.00	12.00	1.00
" " (free cutting)	89.00	9.50	1.50
" " (hardware)	90.00	10.00	0.75
" " (screw wire)	95.00	5.00	0.50

The above mixtures show the charges as weighed off by the caster and do not represent the analyses of the alloys.

There are many different mixtures bearing the same trade name, and it often happens that two entirely different mixtures may, if properly fabricated, be made to answer the same purpose.

Other Copper Alloys.

For a number of purposes a very tight and close-grained metal high in tensile strength is wanted. Alloys of this nature are generally produced by the addition of tin to the base mixture. The casting of alloys of this nature must be carefully carried out, otherwise the surface of the finished material upon being bright-dipped or polished will show numerous fine white streaks, and in some instances slivers. The molten metal should not be brought to a higher heat than is necessary, and the tin should be pushed under the surface of the metal as quickly as possible, shortly before it is poured. The mixture should then be given a thorough stirring. Alloys containing tin seem to develop season cracks much quicker than some of the other mixtures, and this is especially true of the spring tempered brasses.

There are numerous alloys which are made from straight copper and tin mixtures, and these are known under the trade name of "tin bronze." Alloys of this description containing a small percentage of tin (one or two per cent.) will not be found difficult to roll, but the mixtures containing from 5 to 10 per cent. of tin are not only difficult to cast properly, due principally to piping, but the rolling operation must also be carefully carried out. The successful working of these alloys depends a great deal upon the roller, and if he does not understand his business a good casting will not help much. The trick is to gradually get the grain of the metal started right, and after this has once been accomplished no further difficulty is experienced with the rolling operations. Care must be taken not to overheat the

metal during the annealing operation, and it should not be brought to a much higher temperature than a dull cherry-red colour, after which it should be allowed to soak in the furnace until it has attained an even heat throughout its entire mass.

These mixtures when drawn into wire are sometimes hard in spots, and such spots are more or less brittle compared with the rest of the coil of wire. Such hard spots are generally due to overheating during annealing, the coil of wire being "burnt" in places. The addition of a small percentage of phosphorus (generally in the form of phosphor-tin or phosphor-copper) greatly simplifies the casting operation, as it tends to reduce the oxides and causes the molten metal to become more fluid, and produces a more solid and malleable as well as a more ductile casting.

Alloys of this nature are generally put on the market under the name of phosphor bronze, and each mill has its own mixtures, there being no particular standard. As a rule the phosphorus is added to the mixture shortly before it is ready to be poured. The following are some of the weighing charges for alloys containing tin :—

	Copper	Zinc	Tin
Hot forging alloy	60.00	40.00	0.75
" " "	60.00	39.50	1.50
" " "	61.00	40.00	0.50
" " "	61.00	39.00	0.75
Spring brass	62.00	37.00	0.75
" rods	63.00	37.00	0.50
Bell metal	65.00	35.00	0.75
Spring wire	67.00	33.00	0.25
Reed tongues	69.00	30.00	1.00
Condenser tubing	70.00	29.00	1.00
Special cartridge	72.00	28.00	1.00
Spring brass, extra quality	75.00	24.00	1.00
Low brass spring metal	81.00	18.00	1.00
" " dipping metal	83.00	17.00	0.75
Pen metal	85.00	13.00	2.00
Medal metal	86.00	14.00	0.25
Watch fob metal	87.50	12.00	0.50
Oreide metal	87.25	11.50	1.25
Metal	89.00	11.00	0.50
Bronze (high colour)	90.00	10.00	1.00
" (shaft wire)	90.00	7.00	3.00
" small shells	93.00	7.00	0.50
" chain	94.00	1.25	4.75
Medal metal (rich colour)	95.00	3.00	2.00
" "	97.00	1.00	2.00
TIN BRONZES.			
Chain and optical bronze	90.00	—	10.00
" " "	91.00	—	9.00
" " "	92.00	—	8.00
" " "	93.00	—	7.00
" " "	94.00	—	6.00
" " "	95.00	—	5.00
" " "	96.00	—	4.00
" " "	97.00	—	3.00
" " "	98.00	—	2.00

Many manufacturers do not consider it good policy to add phosphorus to mixtures containing zinc, claiming that it has a tendency to produce fine pinholes in the castings. This question may be open to some argument, as the following commercial alloys containing phosphorus will indicate. The addition of too much phosphorus should be avoided, as an overdose will not only cause pinholes in the casting, but it will also increase the difficulties of rolling, due to cracking, etc.

Copper	98.75	98.00	94.00	94.00	93.00	88.00
Tin	1.20	1.00	4.00	4.00	4.50	—
Zinc	—	0.00	—	—	2.00	12.00
5 per cent. phos. tin	—	0.50	2.00		0.50	—
15 per cent. phos. copper	—	—	—	2.00	—	0.50
Stick phos. .. 1 stick	—	—	—	—	—	—

Many manufacturers consider 0.05 phosphorus good practice.

For certain classes of work the trade calls for a metal having a very dense grain and exceedingly high in tensile strength, and for alloys of this nature iron is added to the mixture. The shrinkage of the casting while cooling is excessive in alloys of this nature, and unless the melting and pouring operations are skilfully carried out the castings will pipe. If the iron is not properly introduced into the mixture it will segregate throughout the casting in small nodules which are as hard as steel. It is generally customary to first make an alloy of copper and iron, and the scrap clippings from horseshoe nails give excellent results for this purpose. A little manganese in the form of cupro-manganese materially assists in distributing the iron evenly throughout the mixture.

The alloys containing iron are more or less hard and springy, and some of the mixtures are very refractory, but if the melting and pouring operations have been properly carried out they may be rolled or drawn, though the reductions cannot be as heavy as is the case if alloys are free from iron.

If spelter is used in making up the mixture, care should be taken to select a brand that is free from lead, for if any appreciable amount of lead is contained in the alloy it will break up during the rolling operation, or, if by any chance it withstood the rolling test, trouble would most likely be experienced due to fire cracking. The lead would also cause the alloy to be low in tensile strength, and thus defeat the object aimed at in making up the mixture.

The following are some of the mixtures containing iron :—

Copper ..	57.00	60.00	70.00	82.00	92.50	94.00	60.00
Zinc ..	43.00	40.00	30.00	17.00	2.50	—	38.00
Tin ..	—	—	—	0.75	3.00	4.00	0.75
Iron ..	1.50	0.50	0.75	0.25	2.00	2.00	1.00

The copper-iron-manganese alloy for introducing the iron varies in the different mills; one uses the following alloy :—86 copper, 4 pure manganese, 10 iron.

There is a demand throughout the builders' hardware trade for a metal that is both free-turning and close-grained and will take a high finish. Alloys filling these specifications may be successfully made by adding both tin and lead to the copper-zinc base mixtures. These alloys are very brittle at a low red heat, and extreme care must be taken in handling them. Some of these alloys are as follows :—

	Copper.	Zinc.	Tin.	Lead.
Block-brass	67.50	32.50	0.25	1.50
Hardware bronze	88.00	10.00	1.50	1.00
" "	90.50	9.50	1.37	1.25
" "	90.00	8.75	0.50	0.75
" "	90.00	8.00	0.50	1.50
" "	90.00	8.00	1.50	0.75
" "	92.50	7.50	1.50	1.25
Engraver's bronze	90.00	8.00	1.00	1.00
Screw wire	94.50	5.00	1.00	0.50
Die sinker	86.00	10.00	1.00	3.00

These mixtures should all be poured at as low a heat as is consistent with obtaining a good casting. If poured too hot the metal will not only be more difficult to roll, but will very likely be "specky" as well.

Copper-Nickel Alloys.

The nickel alloys are built up in the same manner from a copper-zinc base, two and one-half parts of copper to one part of zinc answering for most requirements. Tin is seldom used in connection with the nickel alloys, but iron, lead and manganese are often used in the mixtures, as the table below will illustrate. These mixtures, like all those preceding, represent the casters' weighing off charges and not the analyses of the finished

alloys. The manganese is used in small quantities simply as a deoxidiser and not as an integral part of the alloy.

A very hard nickel-silver such as is used for cutlery stock and extra hard springs may be made by adding from one-half to two per cent. of iron to the foregoing mixtures, and by using from four to five ounces of 3 per cent. cupro-manganese as a carrier for the iron.

Kind. Per cent.	Nickel.	Copper.	Zinc.	Iron.	Lead
2	2.00	65.00	33.00	—	—
4	4.00	64.00	32.00	—	—
5	5.00	64.00	31.00	—	—
8	8.00	62.00	30.00	—	—
8 key stock	8.00	66.00	26.00	—	1.50
10	10.00	65.00	26.00	—	—
10 Keystock	10.00	60.00	30.00	—	1.00
12	12.00	62.00	26.00	—	—
12 key stock	12.00	65.00	22.00	—	1.00
14	14.00	61.00	25.00	—	—
14 key stock	14.00	60.00	25.00	—	1.00
15	15.00	60.00	25.00	—	—
15 key stock	15.00	59.00	25.00	—	1.00
16	16.00	60.00	24.00	—	—
16 key stock	16.00	59.00	24.00	—	1.00
18	18.00	58.00	24.00	—	—
18 key stock	18.00	60.00	21.00	—	1.00
20	20.00	57.00	23.00	—	—
21	21.00	57.00	22.00	—	—
24	24.00	55.00	21.00	—	—
25	25.00	53.00	22.00	—	—
30	30.00	50.00	20.00	—	—
32	32.00	51.00	17.00	—	—

Cupro-nickel is made from a straight copper and nickel mixture, the nickel content varying from 5 to 25 per cent. To successfully make this alloy it is absolutely necessary that the melting furnace be so constructed that a very high heat is obtainable. It is possible to tell a good melt by noticing the surface of the molten metal; if the surface appears to be agitated and spits while the metal is being poured it is an indication of a porous casting. The molten metal, in order to make a good, sound casting, should present a smooth and mirror-like surface. Every precaution should be taken to prevent oxidation during the melting operation.

Development Scheme for the Engineering Industries.

The Minister of Reconstruction, it is officially announced, has appointed the following committee of manufacturers and business men to consider the provision of new industries for the engineering trades :—

The Hon. H. D. McLaren, M.P., C.B.E. (chairman).
Mr. Charles Bennion (the British United Shoe Machinery Company).
Sir George Bullough, Bart. (Messrs. Howard & Bullough).
Mr. F. H. Crittall (the Crittal Manufacturing Company).
Mr. R. Dumas (the British Thomson-Houston Company).
Mr. W. B. Lang (Messrs. John Lang & Sons).
Mr. C. A. Lister (Messrs. R. A. Lister & Company).
Mr. P. J. Pybus (the Phœnix Dynamo Manufacturing Company).
Mr. G. H. Sankey (Joseph Sankey & Sons, Limited).
Sir Percy Stothert, K.B.E. (Messrs. Stothert & Pitt).
Mr. J. Taylor (Messrs. Mather & Platt).
Mr. W. Taylor (Messrs. Taylor, Taylor & Hobson).
Mr. W. Thom (Messrs. Yates & Thom).
Sir W. Rowan Thomson, K.B.E. (Messrs. David Rowan & Company).

The duties of the new Committee will be to compile a list of the articles suitable for manufacture by British engineers which were either not made in the United Kingdom or were made in insufficient quantities, and for which there is likely to be a demand after the war. The list is to be classified in three groups : Articles that can be made (1) by women, (2) by men and women, (3) by skilled men, and is to show the industries to which such new manufactures could most suitably be attached. The Committee is also to make recommendations as to the establishment and development of these new industries by the transfer of labour or machines or by other measures; also, as to how such transfer could best be made and what organisation would be needed for the purpose, with due regard to securing the co-operation of labour. To give help on this side of the work, a Labour Advisory Panel is being formed, consisting of representatives of skilled, semi-skilled, and unskilled workers, and of women. With this panel the Committee will work in co-operation on questions concerning labour.

The need for such a list of articles and for some organised effort to make them at home has been amply shown by the war.

HIGH-FREQUENCY ELECTRIC FURNACE. — A furnace presenting a radical departure from usual practice and embodying the first use of oscillatory currents for the generation of heat has been placed on the market by the Pyrolectric Instrument Company, of Trenton, N.J., U.S.A. According to a description in the "Electrical World," by reason of the highly effective induction possible without the interlinkage of a magnetic with an electric circuit, currents can be set up in the crucible in the case of a non-conducting melt, or in the melt itself if this melt has sufficient conductance to permit the flow of current. No iron is used, and thus it is possible to raise the temperature of a melt in a crucible until its resistance becomes low enough to permit the generation of heat in the substance itself, after which the producible temperature is limited only by the durability of the insulation and refractory container. Since the furnace operates by induction, conditions of the melting chamber may be controlled perfectly. Consequently it is possible to produce temperatures exceeding 1,600 deg. C. in the partial vacuum or pressure, with any conceivable atmosphere, and, if desired, without the contaminating influence of carbon. The furnace works on a two-phase commercial circuit, 60-cycles, 220 volts, with balanced load at unity or slightly leading power factor. It has been developed by Dr. E. F. Northrup, in conjunction with the Pyrolectric Instrument Company.

IRON DEPOSITS OF ALSACE-LORRAINE. — At the recent general meeting of the Haspe Iron and Steel Works Company, the chairman, referring to the demand that Alsace-Lorraine should be restored to France, stated that Germany was not in a position to go without the iron ore supply from the occupied district of French Lorraine. Germany only had at her disposal an ore reserve of something over 3,000 million tons, and was therefore substantially dependent upon iron ore imports. In addition to large quantities obtained elsewhere, Germany had principally directed her attention to French Lorraine, and only the annually increasing quantities obtained there had made it possible for France to reach an output which nobody in France had ever thought of before. German enterprise had also taken a share in the development of these iron ore deposits, and France was not dependent upon them, being the richest iron-mine-owning country in Europe if her colonies were included. According to reliable estimates, France had at her disposal reserves of 10,000 million tons of iron ore, the colonies alone representing 400 million tons of this total. The Briey and Longwy basins only contained 3,000 million tons, so that after deducting this quantity, France would still own iron ore reserves of about 7,000 million tons, of which 5,000 million tons were in Normandy of a quality greatly surpassing in iron content the ores in Germany and French Lorraine.

Grey Cast Iron.*

By J. E. Hurst.

One of the chief drawbacks to cast iron from the point of view of high-class engineering construction is its behaviour on reheating, a factor to which, as far as the majority of its uses in high-class engineering work is concerned, considerable importance must be attached. The deterioration of the mechanical properties of this material after prolonged exposure to high temperatures is perhaps the greatest drawback to its use in engine construction.

The phenomenon of growth was first brought seriously to the front by Alex. Outerbridge. It was afterwards thoroughly investigated by Profs. Carpenter and Rugan. As a result of this investigation the factors at work in the production of this permanent swelling or growth in grey cast iron were brought to light. It was shown that by the repeated heating and cooling of grey cast iron, growth can be brought about to an enormous extent; an increase in volume of something like 60 per cent. being obtained in some of the experiments. This increase in volume of the cast iron was shown to be due principally to the penetration of oxidising gases of the muffle into the interior of the cast iron and consequently bringing about oxidation of the constituents internally.

According to Dr. Stead the oxidation of the constituents takes place in the following order :—Iron, silicon, phosphorus, and lastly graphite. This relative order in which the constituents are oxidised does not always appear to be that suggested by Dr. Stead. In this connection is an instance of a grey cast iron chill which had been used on a cylinder barrel core, and which was originally ¾ in. in thickness, but had expanded to the thickness of ⅞ in. The fracture of this chill presented a curious appearance, very much like the fracture of a sample of Blackheart malleable casting, with the exception that the outer ring, which was distinctly outlined and of about ⅛ in. in thickness, was not "steely," but of a light grey appearance. The analyses of the outer ring and the core of this chill are given below :—

	Outer Ring.	Core.
CC	0.17 per cent. (colour).	0.32 per cent. (colour).
Gr	0.90 ,,	0.90 ,,
Tot C (comb)	0.99 ,,	0.99 ,,
Si	2.19 ,,	2.24 ,,
Mn	0.55 ,,	0.58 ,,
P	1.48 ,,	1.51 ,,

Curiously very little difference is apparent in the analyses with the exception of the combined carbon. The most important point to notice is the low graphite content. The original composition of the chill is not known, but it is apparent that there has been a considerable loss, presumably by oxidation, of the carbon contents.

The relative order in which the constituents are attacked and oxidised depends on many factors, which will vary considerably in individual cases. The temperature sustained by the cast iron and character of the surrounding oxidising atmosphere; the structural arrangement of the constituents of the iron at high temperatures, are all factors which influence the growth phenomenon, and vary considerably in individual cases. The latter factor in all probability will be found of considerable importance, and is unfortunately but little understood.

An interesting example of the effect of heat on grey cast iron is the case of a length of ordinary common grey cast-iron rain-water pipe, which had been subjected to a temperature from 900 deg. C. to 950 deg. C. for a considerable number of times. There was no expansion apparent to the naked eye beyond the usual superficial layer of scale, the pipe walls still remaining somewhere in the region of 3-16 in. in thickness. An examination of the micro-structure of specimens taken from this pipe appeared to confirm that the extent of the growth was negligible. A micro-photograph showing the graphite plates indicated that very little expansion of these had taken place. The fracture of this pipe showed an inner ring or core of grey graphitic iron, surrounded on both sides by a ring of a bright steely fracture. This outer ring was almost devoid of graphite plates. It is evident that the inner grey graphitic core had been protected from the influence of the oxidising gases by the formation of this "case" of ferrite with the absence of free graphite, and hence prevented from growing. These pipes were originally very old scrap rain-water pipes, heavily coated inside and out with a thick scale of brown rust (hydrated ferric oxide). This was undoubtedly in a large measure responsible for the original oxidation of the superficial graphite, forming the ferrite case, thus preventing further entry of the oxidising gases, and hence growth. The analysis of the pipe after use was as follows :—CC, nil by colour; Tot. C, 2.20 per cent. by combustion; Si, 2.66 per cent.; Mn, 0.46 per cent.; S, 0.096 per cent.; P, 0.95 per cent.

The production of a decarburised skin on the surface of cast iron may offer a means whereby growth may be prevented from taking place to any large extent. Such a method might be of considerable service in many circumstances, as, for instance, in the case of dies and complicated chills, where the employment of special white irons may introduce serious difficulties apart from growth. In such cases it is suggested that a high-silicon cast iron be employed. This would possess a two-fold advantage, in that the length of time required in the annealing to produce the de-oxidised skin would be considerably reduced, and that the initial combined carbon would be so low that the effect of the deposition of temper carbon, due to the dissociation of the pearlite carbide on the expansion, would be very small and practically negligible. The author has used this process in several cases. There are numerous other instances of grey cast iron which have been subjected to the influence of heat for considerable periods without growth having been brought about.

Further work is still necessary, particularly with a view to deciding the circumstances in which cast iron will *not* grow. It is important to note that the range of temperature covered by Carpenter and Rugan's growth investigations had for its minimum limit 600 deg. C. and for its maximum limit 900 to 950 deg. C. In the region below 600 deg. C. it is certain that volume changes take place. This phenomenon is regarded by Carpenter and Rugan as different from the growth phenomenon investigated by them. Undoubtedly in the region of temperatures beyond the upper limit above mentioned the phenomena met with are likewise of a different character.

The effect of heat on grey cast iron has always been a considerable difficulty to the internal-combustion engine designer in its employment in the construction of pistons and cylinders, particularly in the Diesel engine, and the large gas and oil engines. One of the greatest disadvantages of cast iron in this respect is indirect, and is due to its comparatively low tensile strength and brittleness, necessitating the employment of comparatively thick sections in the piston casting, a fact which, taken together with the low specific thermal conductivity of this material, is a great bar to the rapid dissipation of the heat by conduction to the outer

* Paper read December 9, before a Joint Meeting of the Birmingham Branch of the British Foundrymen's Association and the Staffordshire Iron and Steel Institute.

atmosphere. This has led to the introduction of aluminium alloy pistons on the lighter types of internal-combustion engines.

The cracking phenomenon has been shown to occur in Diesel engine piston heads unaccompanied by the characteristic feature—oxidation of the growth phenomenon. The reason for the absence of oxidation in these circumstances is still somewhat uncertain since it is undoubted that the conditions in the Diesel engine are decidedly oxidising. In all probability this is to be attributed to a number of causes, the main one of which appears to be that the temperature attained is probably considerably higher for a superficial layer at least than that at which growth has been shown to take place. This is of considerable importance, for at a temperature of between 950 deg. C. to 1,000 deg. C. a considerable portion of the free carbon is gradually redissolved in the iron, a fact which it will be obvious considerably retards the entry of the oxidising gases. In addition, it is extremely uncertain as to what action the gases would have upon the constituents of grey cast iron at these high temperatures. Very probably in actual practice the thin layers of carbonaceous matter frequently found deposited on the heads of such pistons, and also the fact that a considerable quantity of oil may collect and remain on the head of the piston, all tend to minimise the chances of the entry of oxidising gases, and hence prevent actual growth due to this cause.

The heating of commercial grey cast iron to temperatures below 950 deg. C. to 1,000 deg. C. invariably results in the dissociation of any pearlite carbide with the production of free carbon in the form of temper carbon. In many cases this dissociation is extremely rapid, and practically the whole of the pearlite carbide can be decomposed in this manner even on quenching from the various temperatures in this range. An examination of specimens which have been subjected to prolonged exposure to heat indicates that a considerable crystalline re-arrangement takes place, the ferrite tending to grow into long dendritic forms. The precipitation of temper carbon is accompanied by a slight volume change, and this fact, together with the structural re-arrangement which takes place on heating, will tend, under the extremely localised conditions of heating of the internal-combustion engine piston head, to set up internal stresses, which, under the conditions prevailing in these engine cylinders, will rapidly lead to fracture. It is practically certain in the case of the Diesel engine, that owing to the high temperatures produced therein, a portion of the graphite carbon is re-absorbed. The extent of this absorption will undoubtedly be limited to the zone of the temperature above 950 deg. C. On cooling down below this temperature, the re-absorbed graphite is rapidly re-precipitated. It is certain that graphite precipitated under these conditions will be in the temper carbon form. One must assume that the numerous small holes to be seen under the microscope in specimens which have been treated in this manner were originally occupied by temper carbon, and which has been detached during the polishing process. On the other hand, as already pointed out by Dr. Hatfield, a considerable quantity of the temper carbon appears to be drawn into position alongside the already existing graphite plates, thereby causing a swelling of these graphite plates. In this latter case it follows that quite a good many of the holes which were originally occupied by graphite plates will, under the conditions of slow cooling, be unoccupied. It will readily be appreciated how disastrous the effect of this will be on the mechanical strength of the cast-iron, under conditions of repeated heating and cooling such as obtain in Diesel engine practice, and although the absorption of a considerable portion of the free carbon largely contributes to the prevention of actual growth, the cast iron is rendered thereby considerably weaker, and is less able to withstand the alternating stresses at such high temperatures obtaining in the engine cylinder during working.

In this connection the author would point out that the increase in size of the graphite plates noticed in heat-treated grey cast irons would appear in all cases to be due to the formation of either layers of iron oxide and silica as in actual "grown" cast irons, or to the "drawing into position of temper carbon" alongside these graphite plates, and he finds it very difficult to obtain evidence of the expansion of the original graphite plates, as such, in grey cast iron on heating.

In many cases the cracking of piston heads is frequently due to mechanical defects such as defective cooling arrangements and badly designed castings. The production of scale or deposit on the interior of Diesel engine piston heads from the cooling water, or the production of hard carbonaceous deposits such as are frequently to be observed in motor-car engine pistons, exert a very large influence on the freedom of the dissipation of heat. Badly designed castings, in which the sections are of widely varying thickness, under the prevailing circumstances in a given engine, materially assist in the production of internal strains and the consequent development of cracks.

The influence of phosphorus has been found by experience to be highly detrimental in Diesel engine pistons. In a large measure this is due to the liquation of the phosphide eutectic constituent in those portions of the piston head subjected to the direct influence of the heat. The melting point of this constituent lies within the region of 950 deg. to 1,000 deg. C. That liquation of this constituent does occur in phosphoretic grey cast irons when heated to temperatures within this range has been fully confirmed on experimental specimens. In quenched specimens of phosphoretic grey cast irons heated to these temperatures it is invariably noticed, apart from its liquation, that its characteristic "skeleton," or eutectic structure, which it normally exhibits in slowly-cooled grey cast irons, is replaced by a close massive constituent which, on strongly etching with $1.2HNO_3$, or heat tinting, shows a structure which is regarded as that of the ternary-iron-carbon-phosphorus eutectic. This second eutectic is formed by the re-absorption of the black "pearlite" areas existing normally within the binary eutectic, and very possibly in addition some of the graphitic carbon. This point is not yet quite definitely settled, but it is observed that the presence of phosphorus would appear to assist in increasing the rapidity of and lowering the temperature at which the re-absorption of the graphite in cast iron takes place when heated to high temperatures. This being the case, it would appear that the presence of phosphide eutectic, in addition to increasing the magnitude of the internal strains in the heated Diesel engine piston head, by reason of the slight volume changes due to its influence on the re-absorption of the graphite, will materially increase the volume of metal in the piston head to be affected in this manner, by reason of its influence on the time and temperature of this re-absorption.

In addition to this, it is very probably a fact, though the author is not aware that it has yet been definitely proved, that the presence of phosphide eutectic constituent materially weakens cast iron at high temperatures. It is therefore legitimate to draw the conclusion that phosphorus is decidedly a very dangerous constituent of grey cast iron for internal combustion engine pistons.

The character of the graphite plates is also a very important point in cast iron intended for internal-combustion engine pistons. Graphite in the form of very fine plates is undoubtedly the most desirable. Cast iron with finely divided graphite plates undoubtedly possesses higher tensile and shock-resisting properties even at the higher temperatures. The chance of any initial penetration of oxidising gases into the interior of the cast iron is considerably lessened. The re-absorption of graphite, though in all probability it may take place somewhat more rapidly in the case of finely-

divided graphite, is localised, and any holes formed as a result of the deposition of this carbon on cooling in juxtaposition with already existing graphite plates, are considerably smaller. It has been frequently noticed that even in pistons containing originally very finely divided graphite plates, these grow considerably in the portions directly subjected to the influence of the heat.

In these days of very effective grinding machinery the author sees no reason why alloy cast-iron pistons of the white-iron type should not be employed in the Diesel engine. The author has himself experimented with several alloys of this type, and from the point of view of strength, shock, and wear-resisting properties, in addition to very effective heat-resisting properties, alloys can be made which possess considerable advantages over grey cast iron, and owing to their lower melting points are at least quite as easy to cast as steel.

The internal combustion engine cylinder or cylinder liner as a general rule is not called upon to withstand anywhere near so high a temperature as the piston. There are, however, many evidences of slight distortions and volume changes in these parts during actual working which are in all probability akin to those experienced in cast-iron fittings or super-heated steam mains. Broadly speaking, it may be taken that what has already been laid down in connection with pistons will equally apply to liners. Obviously, however, there is not the same necessity for keeping the phosphorus in cylinder liners at quite the same low figures. Indeed, it is the author's opinion that the presence of phosphorus eutectic improves the wear-resisting qualities of the liner. From the same point of view, the presence of manganese is also advantageous.

Discussion.

The Branch-President (Mr. J. Shaw) remarked that a recent Paper by Sherwin on the seasoning of grey-iron castings confirmed Mr. Hurst on two points. Sherwin, amongst other experiments, heated two bars to a temperature of 982 deg. C. for 24 hours, and found the pearlite completely decomposed, the graphite flakes larger, and the phosphide structure altered.

Mr. R. Buchanan said that, as was usual when dealing with failures in Diesel engines, Mr. Hurst went for the phosphorus. He (Mr. Buchanan) remembered some years ago discussing this matter with a certain engineer on the Tyne, who said that his experience of phosphorus was rather disastrous. On consideration it appeared that engineers and some others seized upon phosphorus as a ready explanation for failures which might be due to faults in other directions; that in many cases the cracking of piston heads was frequently due to mechanical defects, such as defective cooling arrangements or badly designed castings. Now, it was very reasonable to believe that when a man's designs gave out he was not likely to blame himself first, but would seek for some reason which would most readily take the blame off himself. With regard to the phosphorus content, certain pistons belonging to Diesel engines constructed by Continental firms of repute contained no more than 0.5 per cent. of phosphorus. Yet these pistons gave out and broke down. They were replaced by a Midland firm with iron containing no less than 1 per cent. of phosphorus, and whilst the Continental pistons worked only for a few months, those which replaced them worked for years, and were still working. Whether there was a change of design in the pistons he did not know. He did not agree that such high manganese as shown by the author was an advantage. He would rather go for a lower manganese and a higher sulphur. One of his reasons for this was that a sulphur hardness had been proved to stand better in wear than a manganese hardness. The other reason for using sulphur was that, as Levy pointed out some years ago, the presence of sulphur in cast iron hindered the separation of graphite from the carbide. That was a very desirable thing where high temperatures had to be encountered. Castings which owed their hardness mainly to sulphur would under high temperature conditions not be so likely to give out. The sulphur would tend to keep the casting in being, because when a casting did give out the fracture, as Mr. Hurst had pointed out, lay along the lines of the graphite flakes. Another point he criticised in the analysis quoted was the total carbon. That was a very serious flaw in the mixture. The iron, he thought, would be altogether better if the carbon were somewhere round about 3 per cent. There would then be not so much carbon available to be oxidised. It would be interesting to know why Mr. Hurst recommended a high silicon for dies and things of that kind. He thought it quite probable that oxidation of the outer skin of castings before using them in high-temperature work was a good idea, but he failed to see how anybody could make good dies out of high-silicon iron. Such a die would have to be very tenderly used. Possibly he was overstating the silicon in mentioning 4 per cent., but when one got a lower percentage the total carbon went up. With regard to the influence which phosphorus had on the growth of cast iron under repeated heating, Dr. Carpenter told them that phosphorus had no influence on this growth, or, if any, possibly a slight retarding effect. He (Mr. Buchanan) thought that the influence of phosphorus had been exaggerated, and that phosphorus had sometimes been blamed for troubles which were very probably due to other causes.

Mr. H. F. Hemmings said that the author, in the early part of his Paper, alluded to the use of aluminium pistons on Diesel engines, and said that they were not generally used. He would like Mr. Hurst to know that they had become used much more during the last twelve months. They were used by at least one firm in the Midlands, and also in the South of England, and were generally becoming much more used both in slow running and in high-speed Diesel engines. In the former up to 200 r.p.m., and in the latter up to 1,000 B.H.T. they were being successfully used, and he would be pleased to show the author one that had been running on 10 per cent. overload for twelve months. The pistons were not made of the common zinc-aluminium alloys, but they were classed as special aluminium pistons. With regard to cast iron, speaking from a point of view of practical experience, he entirely agreed with the author as to the use of white iron in Diesel pistons.

Professor T. Turner said that it was to him a new suggestion that growth could be prevented by partially oxidising the exterior of the casting so as to have the ferrite left. He would have assumed that the spaces would remain in the ferrite rim where the carbon had existed. Therefore the air would pass, and there would still be growth. But Mr. Hurst told them that that was not the case; and this fact—assuming it to be a fact—and Mr. Hurst told them his experience was quite conclusive—was important and interesting, and quite a new observation. It seemed to the speaker fairly clear that if they were to have a good cast iron, closed grained, capable of standing both high tensile tests and also high temperature, they must have, as pointed out in the Paper, small graphite. That small graphite was formed at a lower temperature than large graphite; it was formed when the metal was already solid—in the solid metal. He agreed with Mr. Hurst, too, that they should have low phosphorus. But the difference between Mr. Buchanan and the author was, perhaps, not quite so great as appeared, because when they spoke of low phosphorus in ordinary foundry work, it was high phosphorus for other purposes. For example, what they called low phosphorus, say, 0.5 per cent., for ordinary purposes, would be regarded as high phosphorus by the malleable ironfounder. He did not think Mr. Buchanan would suggest as high as 1.75 phosphorus or anything like that, so the difference came down to a little less than 0.5 per cent., and personally, he would not like to go much beyond 0.75 per cent. It was within that limit obviously that the best results would be obtained as far as behaviour under repeated

heating was concerned. There was no doubt that the liquidity of this phosphorus eutectic had a good deal to do with the matter. That material could be squeezed out at about 950 deg. C., as Dr. Stead had shown; and it was obvious, as the author suggested, that the metal must be weaker if it contained very much phosphorus. If part of the metal became liquid before the rest it was perfectly clear that there would be a weak material. The next point was that they must only have a moderate proportion of silicon if they were to have this small-grained cast iron. The lower the carbon the lower would be the silicon to give them the same results; and it would also depend upon the amount of sulphur. In ordinary circumstances, if they were to have a low silicon—which was good from the point of view of preventing growth—they must have a fairly low sulphur, because they must have a balance between the sulphur and the silicon. Sulphur at low temperatures did give a hardness which was very advantageous; it was one of the elements, so to speak, with which they could play in order to get the hardness which might be desired. Then the presence of such metals as dissolved in the iron to give a solid solution, and therefore to form a ferrite of somewhat modified properties, was no doubt advantageous. Silicon gave silicon-ferrite, or a series of solid solutions with ferrite. This was also the case with manganese and with chromium. Apart from the fact that nickel had a tendency to make the iron grey, he thought that nickel would act in the same way, but no doubt it would be necessary to pay special attention to the network structure. To anybody who had had an opportunity of seeing the microstructure of these very strong cast irons, it was a common, almost a universal, observation that they had associated with them a structure of this curious network character. The question was suggested by the Paper, Why should a better result be got with graphite in the finely powdered state—he meant better mechanical properties; he was not dealing with the question of growth at the moment—than with carbon in the form of coarse graphite? The explanation, in connection with malleable cast iron, was given by an American writer, and appeared to be very simple when it had been pointed out, though he did not thing of it in quite the same way till he saw it suggested by this writer. If they took iron with an ordinary large grey graphite, it was deposited at the side of the larger crystal boundaries, and they got grains, as it were, separated by a weak material. The result was that when the iron was subjected to stress in any way there was a tendency for the fracture to pass along the lines of cleavage determined by the coarse graphite. Now, if they had the graphite distributed in the form of very small particles through the mass, there were no such lines of cleavage, but there were a number of points of weakness spread through the mass, as in the case of a sponge. Now, if the fracture started and struck one of those small holes it could not proceed any further, because there was no line for it to take except through the soft, tough metal which it would have to pass through to reach another hole. The effect of the first fracture, therefore, might be practically negligible.

Mr. J. E. Fletcher (President of the Staffordshire Iron and Steel Institute) said that with regard to the order of oxidation during heating, Mr. Hurst had pointed out the great probability that at above 950 deg. C. the heating of grey cast iron brought about a different set of conditions from those which occurred below that temperature. They would find that Mr. Hurst, in the early part of his Paper, referred most particularly to the change that occurred above 950 deg. C., namely, at the temperatures which prevailed in Diesel-engine cylinders just below the explosion point, and had said that they were obliged to look at that fact very particularly. His observations confirmed this. The actions were complicated because of the presence of silicon and phosphorus. He found that in irons which were low in silicon and phosphorus, and the constitutional analysis of which when quenched from the molten was C.Mn.Fe eutectic plus gamma iron crystallites, more or less carbonised, such iron, when reheated to, say, 900 deg. C., gradually changed in structure. The pearlitic ferrite areas (the primary iron crystallites which first froze in the sea of eutectic) became further cemented or carburised by the adjacent carbide of the eutectic, which was seen to break up and become absorbed in the pearlitic areas. This absorption proceeded until those areas became filled with saturated austenite (1.8 per cent. C.). Quenching briskly revealed this constituent:—

Primary, 80.0 per cent. eutectic, 20.0 per cent. pearlite; secondary, 74.0 per cent. eutectic, 26.0 per cent. austenie (1.8 per cent.)

He found this action to take place in a white Swedish iron of 0.5 per cent. Si content, low in Mn., P and S, at 900 deg. C. Manganese speeded up the austenitic cementation of the pearlite areas at about the same temperature. Phosphorus added appeared to make but little difference, though at 1,000 to 1,050 C. there was evidence of segregation of the phosphide eutectic, and it was clear that this constituent became liquid at those temperatures, and so mobile that it found its way to the boundaries of the austenite crystallites. Silicon retarded the carburisation of the pearlite areas, and he found that 1.5 per cent. Si required to be reheated to about 1,100 deg. C. before austenitising began. This confirmed some of the remarks of Mr. Hurst. The reheating to which he had referred was carried out in a muffle. Afterwards he tried the result of reheating the same alloys in atmospheres of CO and H. The former gas increased the speed of austenitisation of the pearlitic areas, and he had reason to believe that at 1,100 deg. C. there was a growth of carbide Fe_3C, the carbide portion of the eutectic being increased, whilst massive cementite plates began to appear. With hydrogen the reverse was the case; the iron carbide at the surface of the sample became gasified, passing off as a hydrocarbon; whether the gas was methane or ethane he could not say. This action revealed the true iron crystallite boundaries, which could be clearly seen before again polishing on a ground surface which had been purposely prepared before reheating.

He had a number of micro-photographs in which they would see that under the action of hydrogen the whole of the polished surface of the specimen became cracked with lines which followed the finer lines of the ferrite crystals. He came to the conclusion that along these boundaries the occluded gases escaped, and also that the attacking hydrogen gas proceeded along them when gasifying the carbides. He mentioned that because Mr. Hurst had alluded to the decarburisation of the surface of cast iron. In some of the experiments it was found that no growth, no swelling occurred after this decarburising had been performed by means of hydrogen. This might in some way help to explain the action of decarburisation at the surface of Diesel piston heads. His experience confirmed that of Mr. Hurst in his statement that when the graphite flakes at the outer surfaces of pieces which had to withstand repeated contact with oxidising gases at temperatures of 1,000 deg. C. and over were kept of small dimension by either decarburising or by chilling, "growth" did not proceed rapidly. He made a number of experiments in this connection in order to see what was the best metal for ingot moulds and also the best for chills. In the case of anvil blocks of shingling hammers, where the conditions were severe, chilling the surface and using about 1.5 per cent. of manganese gave longer life by increasing the temperature at which the metal began to oxidise, and by densening the surface through the grip of the manganese on the eutectic portion of the structure. He had found chromium to behave in a similar way in cast chilled drawing dies. More phosphorus might be used when the manganese or chromium was raised (within limits). He agreed that lower carbon irons (white ferritic) did not grow, but he

thought that great care was necessary in the cooling of such castings when cast, for there was no doubt that there was a considerable difference in the rate of contraction and expansion of the two dominant constituents, ferrite (more or less austenitised) and the eutectic, which was differently decomposed in various parts of the same casting. The function of fine graphite and temper carbon in a cast-iron structure in the matter of strain distributing during heating and cooling was important, and he would not be surprised to learn that castings made from cold-blast pig-iron, low in total carbon and having 1 to 1.5 per cent. Mn with about 1.5 per cent. Si and with, say, 0.5 per cent. P, carefully chilled at the surfaces exposed to the heat, gave safer results in the long run than those made from metals of the semi-steel character, which, unless very carefully heat treated, were liable to sudden fracture when under strain. The re-absorption of graphite was an all-important detail. It could be largely controlled by judicious use of manganese, and by the employment of irons which had not been produced in the blast furnace under conditions of excessive temperatures and tuyere zone oxidation inseparable from rapid driving and high stove temperature.

With reference to manganese, at a meeting held some little time ago in Dudley he alluded to a cast iron which had been used for work similar to that Mr. Hurst had brought before them, an iron with a particularly high manganese content, more than 3 per cent. But in order to neutralise that, the silicon was abnormally high. They needed to know a good deal more about the balance of effect between silicon and manganese. Alloys could be made with very much higher percentages of both having high tensile strengths and very wonderful wearing properties, and of a character with which commercially they were very little acquainted. The French people had experimented very considerably with such irons, and he had some micrographs of irons of the nature he had described. The analyses were :—

(1)		(2)
C.C. 1.2	...	C.C. 0.20
C.G. 1.95	...	C.G. 2.18
Mn. 3.26	...	Mn. 2.65
Si. 6.5	...	Si. 6.16

To illustrate one or two points which might be suggestive to some of them he had brought a few micrographic slides, which he hoped might add interest and help to explain the structures of the cast irons mentioned, and which had a direct bearing on Mr. Hurst's contention.

Mr. F. J. Cook remarked that from a perusal of Mr. Hurst's paper one would be bound to come to the conclusion that for Diesel engine work the vital item was low phosphorus. He (the speaker) certainly could not agree with Mr. Hurst on this point. The bad effects of high phosphorus were only apparent when in conjunction with metal which was unsuited for that particular class of work, and he was of the opinion that it was because Mr. Hurst — judging from the analyses and tests given in this and other of his papers —had dealt with mixtures which were not calculated to give the best results that he had apparently become biassed in that direction. Phosphorus certainly was not the vital point; the vital matter in metal for Diesel engine castings was the quantity and condition of the carbon present, which was based on a proper equilibrium of the carbon and silicon in the mixture. This equilibrium was expressed in a formula, which he (Mr. Cook) had given on several occasions, i.e. :—

$$SC = \frac{C}{4.26} = \frac{Sil.}{3.4}$$

where SC = Equilibrium of Carbon and Silicon; C = total Carbon in the metal; and Sil = Silicon in the metal.

The best results were obtained for that particular class of work when the formula gave a result equal to 0.76 to 0.8. When this result existed phosphorus could be as high as 1 per cent., and even higher, without causing any bad effects. Further proof of this was shown in the following table of particulars and results in working of several Continental and British firms making pistons. The figures formed part of information gleaned during several years' study of the problems connected with Diesel engine castings :—

	Hurst.	German.	Another German.	Continental	Replaced by	Scotch.	Suggested by F. J. Cook
Phos.	0.52	0.33	0.59	0.54	1.34	0.54	0.8 to 1%
Mn. ...	1.44	0.72	0.59	1.08	0.28	0.97	Not over 0.5
SC. ...	0.9	0.83	0.91	0.92	0.8	0.77	0.76 to 0.8
Results	—	Good	Bad	Bad	Good	Good	Has never given star cracks, low tensile results or bad wearing properties.

In the table the first column was the analysis suggested by Mr. Hurst, which contained phosphorus 0.52 per cent., manganese 1.44 per cent., and a silicon-carbon equilibrium of 0.9. The next, which was of German origin, had Mn. 0.72 per cent., P. 0.33, and equilibrium of 0.83; this metal gave reasonably good results, and the pistons were still working. After about six months' running they were found to be slightly deformed, and showed signs of wear, but, generally speaking, they were good. In "another German" mixture with P. 0.59 per cent., and equilibrium of 0.91, the piston did not last six months, but certainly not because the phosphorus was not low enough or the manganese not sufficiently high. The next one, described as "Continental," was probably the case referred to by Mr. Buchanan, and contained P. 0.54 per cent., Mn. 1.08 per cent., and a silicon-carbon equilibrium of 0.92. The results in working were bad from the first. Without any alteration in design, and specially to prove the effects of phosphorus, the replace pistons were made with phosphorus as high as 1.34 per cent., or nearly three times the amount suggested by Mr. Hurst, whilst the manganese was also very low, 0.28 per cent. These pistons were still giving excellent results, and the engineer's first report was that they ran better than the original ones ever did. The particulars given as "Scotch" had also given very good results. The last one given was that recommended by the speaker as most suitable for Diesel pistons and liners. In each of the instances given—and many more could be cited if necessary—the results in working bore no relation to either the phosphorus or manganese content of the metal, but were closely related to the results suggested by the silicon-carbon equilibrium

Mr. Cook wished to make it quite clear that he was not specially advocating high phosphorus, but desired to show that low phosphorus content alone was not so vital as Mr. Hurst suggested. Whilst that was the case, he was quite of the opinion that with the silicon-carbon equilibrium as suggested, castings with 0.8 to 1 per cent. of phosphorus were to be preferred, from the fact that the metal had lower contraction. and the castings were in consequence freer from initial strains. In the admirable paper referred to by Mr. Hurst, and given by him before the Manchester Association of Engineers, he stated that the wearing properties of cast iron were closely related to the tensile strength of the metal, a statement with which Mr. Cook quite agreed. Unfortunately, however, all the test results published by Mr. Hurst had been quite poor for Diesel engine piston and liner castings; for instance, in Table II. the highest tensile result given was 12.5 tons, whilst the average was 11.6 tons per sq. in. These results were quite in accordance with the silicon-carbon equilibrium of 0.9, in Mr. Hurst's suggested analysis, and offered further proof of the unsuitability of the metal with which he had been dealing.

Continuing, Mr. Cook said that six tensile tests taken from consecutive casts recently made by Mr. J. J.

Howell, with metal conforming to the silicon-carbon equilibrium, as recommended by the speaker, had given as the highest 18.86 tons, and an average of 17.4 tons per sq. in., the metal containing 1 per cent. of phosphorus, again proving that phosphorus to that extent was not detrimental to high tensile test results. Tensile test results might be misleading unless full particulars of the size of bars, etc., were given. In the case cited the bars were cast 1¼ in. in diameter, paralleled and turned down to ½ in. square area or thereabouts in the middle part before testing; the bars were also cast on the castings they were to represent—not separately—and left in the moulds till cold. Mr. Hurst, in his Manchester paper, had also explained very graphically the phenomena of wear and surface flow, with all of which he (Mr. Cook) quite agreed. The bad wearing properties by pitting, etc., dealt with by Mr. Hurst, he (Mr. Cook) had always attributed to rather poor iron, containing high manganese. During many years' experience with high-speed engine cylinders working with superheated steams, he had had opportunity of examining parts of badly-worn cylinders of various makes, and from many parts of the world, and whilst in many cases the metal employed was obviously unsuitable, there were many cases where very little could be complained of, with the exception that they were very low in sulphur and high in manganese. Manganese formed very spikey crystals, which could be readily seen in the fracture of high manganiferous pig-irons. These being not well supported in a poor iron, broke down under rubbing, causing pitting and bad wear, which continued with disastrous results. With a well-packed metal, such as was associated with the silicon-carbon equilibrium suggested, containing high sulphur (say, about 0.12 per cent.), the crystals did not break down, but had the spreading properties which took up the high polish Mr. Hurst had shown to be desirable.

Mr. Isaac Lester said that of the two points which interested him most in the discussion one was that mentioned by Mr. Fletcher, who rather suggested that cast iron was not sufficiently complex in itself, and that despite its complexity one should add managnese and chromium. He would like to see tests, both physical and chemical, showing the actual strength and wearing properties. They did not always want intense hardness. Mr. Cook gave as high as 18.45 tons per square inch tensile strength, but perhaps he would be good enough to tell them what the torsion tests were on that particular iron. Moreover, the sulphur was not given, and he was rather unsatisfied in reading the results given. He would like to see the whole thing, for the sulphur was a great factor in dealing with anything in regard to combined carbon. Such particulars would enable them to understand what could be considered the important factor. Mr. Fletcher, like himself, held a brief for cold-blast iron, but as a user of it he knew that at high temperatures it did not always produce the results they desired.

Mr. Cook, replying to Mr. Lester, said that he quite agreed with Mr. Buchanan in preferring high sulphur to high manganese. He did not believe in going to over 0.5 of manganese, whilst with sulphur he could go up to 1.2.

Mr. A. P. Holliday said that he had had two engines under his charge for over four years in which the pistons of one had a very low phosphorus iron, whilst the other had pistons of relatively high phosphorus iron. Careful gaugings had been taken from time to time to ascertain the amount of wear taking place, and apparently there was very little to choose between them; if anything the low phosphorus iron appeared to be wearing the more quickly of the two, although in both cases the amount of wear was very small. The low phosphorus iron had higher manganese than the other (in fact, he thought it was the analysis given by Mr. Cook of 0.72 manganese); the other pistons had a much lower manganese, so that, judging from his experience, there appeared to be something else necessary to be taken into consideration besides the chemical constituents, and he believed that a good deal depended upon the design of the piston and the method of getting the heat away. A good many pistons had passed through his hands, but in no case, after severe testing, had they developed the star cracks which were characteristic of bad pistons. These pistons had varied in analysis between the two extremes mentioned. Experiments had been made with chilled pistons, but great care was necessary to see that this was not overdone, as otherwise a complete fracture occurred, even before the engine reached full load. Other firms had been successful in repairing pistons with central star cracks by removing the defective part and fitting a special design of plug, and there were cases in which considerable service had been obtained under these conditions. The best type of piston head used by his firm was one in which the crown was unsupported by ribs, particular care being taken to see that there was an uninterrupted flow of heat from the centre to the outer edge, where it was readily taken away through the cooling medium of the water-jacketted cylinder walls. There appeared to be differences of opinion regarding the correct design of piston head, some firms adopting the ribbed pattern, though, in his opinion, this design was more prone to failure.

Mr. J. H. Westwood said that he had for a long time been making observations on the growth of cast iron, and had made a number of experiments with fire bars, using different mixtures of malleable cast iron, also grey cast iron. He found that grey cast iron containing about 0.15 per cent. phosphorus gave the best results. After a number of reheatings there seemed to be a permanent set, the fire bar ceasing to expand in length. He thought that this was due to the iron having having expanded to its elastic limit, because there appeared to be a permanent set, the fire bars not getting any longer; but he had not the instruments to take exact measurements.

Mr. Hurst, owing to the length of the discussion, proposed to reply in publication. There were one or two points, however, which he would like to mention. One was the comparison between sulphur hardness and manganese hardness which was mentioned by Mr. Buchanan, who stated that sulphur hardness had been considered to give better wear properties in cast iron than manganese hardness. As he was very interested in all problems of wear, and had been unable to obtain any authority to whom he could refer for information on the subject, he would be glad if Mr. Buchanan would enlighten him as to where this information could be obtained. He had found an enormous difficulty in looking up research work of previous investigators and in getting anything definite on that subject. He had spent a considerable time in going through researches on wear, and beyond one or two of an enormous number of publications he had looked at, he had found very few satisfactory references. They would be surprised at the lack of information on this subject of wear in publications.

Mr. Hurst, referring to high-silicon alloys for dies, said that he was not speaking in his Paper of the dies referred to by Mr. Buchanan; he was referring to dies for die casting. (Mr. Buchanan: I was thinking of stamping dies.) He had no intention whatever of recommending that material for stamping dies. He was very much interested in Mr. Cook's remarks with regard to the network structure from the point of view of tensile strength. He would like to call attention to the fact that Mr. Cook's criticism on all his Papers was that the irons he put forward all gave a low tensile strength, and yet some of these had the network structure finely developed. Therefore, he did not see how Mr. Cook could make out that the network structure necessarily ensured high tensile strength. He did, however, agree with Mr. Cook that a network structure was an advantage in Diesel pistons and liners. Whether cracking was brought about by excessively high phosphorus was a matter with which, amongst other things, he must deal when he gave his reply in writing.

Moulding of Shells and Grenades in French Foundries.

The importance of the modern foundry in producing war material is very great, and has been increased by the installation of modern labour-saving machinery. The foundry has too long been neglected and allowed to work under conditions which other branches of the engineering trade would not tolerate, but in this, as in many other directions, the war has brought changes into numerous foundries, and in France it has not only been necessary to produce a great number of castings for every description of machine in-

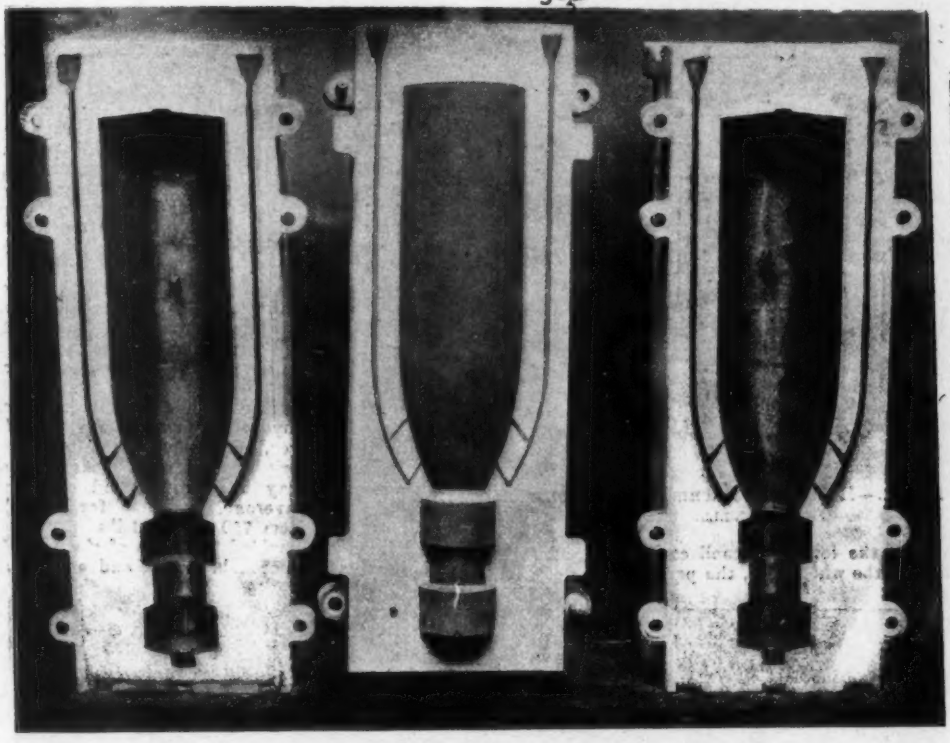

FIG. 1.—PATTERN-PLATE AND TWO HALF MOULDS FOR 220 MM. SHELL.

directly used for military purposes, but founders have been compelled to enter directly into the munition field. For example, one of the greatest achievements of the French foundries, from the point of view of munitions, is probably the success which has been obtained in the moulding of cast iron and "semi-steel" shells.

Fig. 1 shows the pattern plate and the two half-moulds of a 220 m/m "semi-steel" shell. This pattern plate is on the reversible process, which means that the pattern is split in half. By this system of pattern plates the half-moulds are continually made off this reversible (half) pattern plate and assembled. Each half-mould contains half the pouring gates, runner and core prints, which are plainly seen in Fig. 1. The core prints are made at the bottom of the moulds for supporting the cores and a chaplet is used for the support at sides, the latter being taken out after the placing of the mould in its vertical position for pouring. This leaves the core entirely supported by the core prints at bottom of mould.

Fig. 2 shows a hydraulic moulding machine (Type A.3) which is largely used in France for moulding these shells. The illustration shows this type of machine equipped for moulding 155 m/m shells, one casting per mould.

The 90 m/m shells are made on the same machine in the same manner, but with two castings per mould, and the only difference is that these 90 m/m shells have one runner which feeds the metal to the two castings, whereas the larger shells have two runners, one each side of the casting. The output of the A.3 machine is, in the case of the 90 m/m shells, 15 to 20 moulds (30 to 40 castings) per hour.

The shells produced by these processes are of an excellent quality in all respects, and have met with full approval in France, with, of course, the exception of the enemy.

Further, take the hand grenades and the development of the processes for the quick production of the sand cores. Fig. 3 shows these processes. A complete grenade will be seen at J and sectional parts will be seer at I I. The castings

are perfectly round, like a ball, but the inside is a network of grooves. The core box for making the cores will be seen in Fig. 3 at B. In this

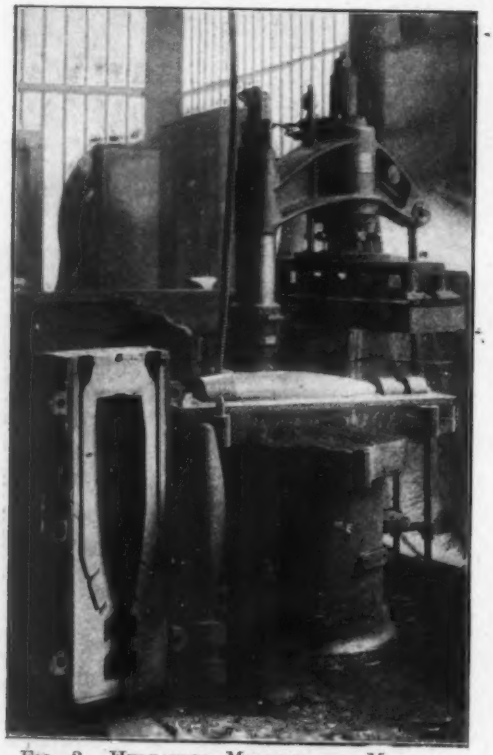

FIG. 2.—HYDRAULIC MACHINE FOR MOULDING SHELLS.

core box the lower or small core A is made. To build up the whole core, the portion A is put in an inverted position in the bottom part of the core box D, and a collar is put round the six sides of the core box, and this box is filled with sand, and after it has been rammed the top section of the box F is put into position. Additional sand is then put through the hole in the top, the springs marked G are placed in position, in order to hold the drag and cope together, and more sand is added through the hole in the top. The sand being rammed, a plug is inserted in this hole, the springs are released, and the collar can then be taken off so that the sides of the box may be expanded to allow of the core being removed. Complete cores ready in position to be taken to the core ovens will be seen at H.

Another type of grenade is made on the F4 high-speed moulding machines, which are built for flat work, the two boxes being rammed simultaneously on both sides of the pattern plate. These double-faced match plates are very cheap and quick to make, being of white metal. The machines work with unmachined boxes, which are barred and can be poured either from top or on the flat. No clamp or weight is necessary for pouring from top or on the flat; the boxes being barred are clamped on the machines by hooks. These machines are very rapid in working, and are capable of easily turning out 25 to 30 moulds per hour ($21\frac{1}{4}$ in. × $14\frac{1}{4}$ in.) according to the nature of the work upon which engaged. Fig 4 shows the F4 machine. The mould contains 18 grenade castings, and they are arranged for pouring on the flat, two gates being provided in the cope part. These gates are made on the machine itself during the ramming operation. The difference between some grenades is that the grooves are outside, instead of inside, as those first mentioned. Of course, this greatly simplifies the coring processes, as the cores are just plain oval ones, having axial core prints each end.

There has always been some controversy regarding the use of hydraulic pressure for moulding machines. However, hydraulically-operated moulding machines work with a steady motion, and high pressures may be obtained and easily controlled. The average pressures for moulding machines vary from 750 to 1,500 lbs. per square inch, which has enabled the rams of the machines to be kept at a reasonable limit, and at the same time obtain an adequate pressure. These circumstances have, therefore, allowed the building of large machines with a static pressure as high

FIG. 3.—PROCESS OF MAKING HAND GRENADES.

as 80 tons. It is only necessary to have small piping for all connections, piping ½ in. to ⅞ in. inside diameter being of sufficient strength and size. It is claimed that the power required for working a hydraulic plant is much less, and consequently it must be much cheaper to run such a plant, in comparison with that of compressed air.

From the labour point of view, in France labourers are chiefly used on moulding machines. This is considered preferable to employing moulders who have a skilled knowledge of the foundry trade. Of course, as in all countries affected by the war, the women of France are doing a large amount of the war work, and on moulding machines excellent results have been obtained, more so in the cases where the moulds are of the medium size.

As regards wages, a great number of foundries in France give preference to the piece-work system, though there are many employers who are favourable towards the premium system. These

FIG. 4.—MOULDING MACHINE FOR HAND GRENADES.

latter men are of the opinion that the piece-work price when settled is a cause of difficulty with the workmen. The premium system, they claim, makes these difficulties more easily adjustable. Those in favour of the piece-work, however, contend that if an equitable piece-work price is settled, after studying all conditions entering into the price, no difficulty need be experienced, and that piece-work payment tends to increase output.

The above moulding machines and appliances are patented and manufactured by the Société Anonyme des Etablissements Ph. Bonvillain & E. Ronceray, Paris, whose agents for the British Isles (the Universal System of Machine Moulding & Machinery Company, Limited, 97, Queen Victoria Street, London, E.C.4) are supplying many of these machines in this country for all descriptions of castings for munition work. All machines are of their pre-war standard types.

Iron and Steel Trades' Advisory Committee.

The Minister of Labour has appointed the following to be the Iron and Steel and Kindred Trades' Central Advisory Committee (Employers) to advise and assist the Ministry of Labour on questions arising in the administration of the Employment Exchanges, which affect employers in that industry :—

Mr. George Ainsworth, Steel Ingot Makers' Association.

Mr. J. J. Burton, J.P. (Middlesbrough), Cleveland Ironmasters' Association.

Mr. Laurence Ennis (Middlesbrough), North of England Iron and Steel Manufacturers' Association.

Mr. F. W. Gilbertson, South Wales Siemens Steel Association.

Mr. F. W. Gibbons, J.P., Welsh Plate and Sheet Manufacturers 'Association.

Mr. John Graham, West Coast Ironmasters' Association.

Mr. J. B. Harding, North Staffordshire Ironmasters' Association.

Mr. George Macpherson, South Staffordshire Ironmasters' Association.

Mr. Frederick Mills, J.P., D.L., South Wales Iron and Steel Makers' Association.

Mr. M. L. Simpson, Scottish Steelmakers' Wages Association.

The committee held their first meeting last month, when Mr. J. J. Burton was elected chairman.

Mr. F. W. Gilbertson, of the South Wales Siemens Steel Association, was elected vice-chairman of the committee.

The committee discussed a proposal that managers of Employment Exchanges, when selecting applicants to fill vacancies, should give a preference, other things being equal, to men who have been discharged from His Majesty's forces owing to wounds or other disability. It was agreed that the application of this principle in the iron and steel trade should be discussed at a joint meeting with the corresponding Operatives' Committee.

WORKING RESULTS OF A RENNERFELT ELECTRIC STEEL FURNACE.—In the course of the discussion of a Paper on the "Prospects of the Electric Steel Furnace in Sweden," by Mr. Otto Frick, Mr. I. Rennerfelt and Chief Engineer H. von Eckermann, put in the following figures as actual results, with a 1½-ton Rennerfelt furnace (arc-type), at Ljusne, in Sweden, during the five days, from Nov. 21 to 25, 1916 :—According to them, 12 charges were dealt with in the furnace in question, the average net time per charge being 6 hours 39 minutes. The average input was 1.27 metric tons, of which 19.5 per cent. consisted of common Swedish grey pig-iron, 6.5 per cent. of billet croppings, 64.5 per cent of bar croppings, and 9.5 per cent of scrap. The additions were in eleven of the charges, ferro-manganese and ferro-silicon, plus in five charges, small doses of aluminium, some flux being added (Kiiruna ore = 1.8 per cent. average of the charge) in every case, plus a small quantity of lime in one case. The average output (including scrap left) was 1.236 metric tons per charge; hence the loss was 2.44 per cent. The scrap left over represented 10.12 per cent. of the weight of the ingots and direct castings produced. The consumption of electrodes was 5.1 kgs. (11.22 lbs.) per metric ton (2.205 lbs.), and the energy consumed 1,010 kw.-hours per metric ton of steel (with 0.21 per cent. carbon) produced. The work of the furnace was intermittent, hence the larger consumption of energy. With continuous working and producing steel with a carbon content of 1.20 per cent., the chief engineer thought the average current consumption could be reduced to 800 kw.-hours per ton of steel produced.

Malleable Cast Iron.

Following is the discussion on the paper by Mr. E. Adamson, read before a joint meeting of the Staffordshire Iron and Steel Institute and the Birmingham Branch of the British Foundrymen's Association. For the paper see our last issue, page 74. Mr. J. E. Fletcher, M.I.Mech.E., the President of the Staffordshire Institute, occupied the chair.

Mr. F. J. Cook said that in regard to malleable iron it was probably true that as to fracture they had a wider range of analysis to produce good results than in regard to some other products. They could not emphasise too strongly the need of a white fracture, although in that respect they might be in contradiction with some scientists as to the relation of analysis and fracture. No doubt it was perfectly true that it was necessary to anneal at a higher temperature and for a greater length of time for malleable dealt with in the cupola than for material produced in the Siemens furnace.

Professor Turner said that Mr. Adamson had stated that sulphur and silicon in pig-iron were not interdependent. That was in a measure true, but that was because there were so many other variables in pig-iron. For example, there was manganese, phosphorus and sometimes even chromium and other elements beside the amount of carbon and the difference in temperature of the furnace. But if they were dealing with *pure* material, and they certainly did approach pure material in the irons used for malleable purposes, then the sulphur and the silicon were interchangeable. If more silicon were added it should drive out the sulphur, and they could add more sulphur by introducing conditions which diminished the silicon. That was proved by mixing pure materials together and giving them an opportunity of coming to equilibrium. An examination of the top and bottom portions of the melt would show that the sulphur and silicon were interdependent. He had done experiments which had never been questioned, and by adding high silicon and high sulphur and allowing them to come to equilibrium could be found what the percentages of silicon and sulphur were in the several parts. It did not, however, follow, when they were dealing with pig-iron, that because there was, say, 0.2 per cent. of sulphur there would be 1½ or 2 per cent. of silicon, because there were other circumstances to be considered, especially the influence of temperature. When dealing with equilibrium one must have the temperature defined, and the materials must be pure. It would be a mistake to allow it to go forth that when pure materials were put together at a given temperature they would not get definite equilibrium. He thought, too, that Mr. Adamson went a little far when he said with regard to analysis and fracture that one was "absolutely no indication of the other." When he (Professor Turner) saw the fracture of a perfectly white iron he knew that there was no graphite in it; but when he saw grey iron, No. 1, he knew there was graphite, and also silicon, in it. So that fracture was at all events some indication, and very often a considerable, though not an infallible indication of the character of the metal. Mr. Adamson might be justified in saying that fracture was not an infallible indication of the composition. Mr. Cook had referred to the fact that fracture in white iron used for malleable purposes was often of more importance than analysis, because they knew that if they had the iron perfectly white they could get a good result in malleablising, whereas with otherwise similar composition if not perfectly white they would not get the same result. But what did that mean? It meant that the eye gave an analysis in that particular case. It revealed the fact as to whether or not there was free graphite; and if there was free graphite then they could not get a good result. But they could not tell by the eye whether there was sulphur, phosphorus, and so on. He thought that particular instance bore out the suggestion that the analysis and the fracture should largely go together. When they knew from the fracture what the composition was, then in such a case they were able to predict what the result would be. The judging of the pig-iron entirely by analysis was not found to be satisfactory on what was called the border-line iron. But with a definite iron—white, grey iron, and so forth—they would find that analysis was usually a very fair indication of fracture; and in the other cases there were other conditions that interfered but did not militate against the underlying scientific fact of what would occur if they were dealing with known materials under standard conditions. Either definite properties must follow from definite composition, or they must go back to the Middle Ages and imagine some devil in the iron making things go round the wrong way. Under a wide range of commercial conditions, however, they could not always reproduce the same results. Malleable cast iron was of great importance at present, and Mr. Adamson had set out very well and plainly the general principles of the annealing process. There was nothing more important than proper annealing. It did not matter how good or how bad the materials might be, or how much attention and skill were devoted to it in the intermediate processes, if they did not give exactly the right time and the right temperature they would not get the best results. It was astonishing, judging from the reports in the American technical Press, what immense improvements had been effected within the last five or ten years in the quality of their malleable castings. Starting with cheaper iron, and dealing with a straight run of blast-furnace metal, they got excellent results in the way of ductility and elongation with great uniformity. If the Americans could do that it was up to Englishmen to try to do the same thing, and so to extend the malleable iron trade in this country. There was no reason why the malleable cast-iron trade should not bear the same proportion to the general iron trade of this country as it did to that of America.

Mr. A. E. Hurst (of Walsall) said that a recent complaint against malleable-iron founders was that they worked by fracture instead of by analysis. Apart from Mr. Adamson's remarks, he could confidently say that while they worked by fracture chiefly in the Birmingham district, they did so with considerable success. The argument practically amounted to this, that they were to keep a chemist to analyse all the materials used. Most of the malleable concerns were small ones and could not afford to keep a chemist. If the iron were analysed at a blast furnace where a chemist was kept, there was no necessity for the malleable-iron founder to keep one also. If the blast-furnaceman sent the ironfounder the sort of stuff he wanted, and which he could use, then the ironfounder ought to be able to proceed quite satisfactorily by fracture alone. He presumed it sometimes happened at most blast furnaces that something went wrong with the melting, but that was no reason why they should send the material to the unfortunate ironfounder and get him into trouble. He could well understand that if they made a thousand tons of iron which was not quite right, the makers could not throw it into the canal. But there should be other uses for it without foisting it on the ironfounder who had been accustomed to use certain grades of irons and produce certain results. He had always understood that with high silicon a white fracture could not be got. That was one of the difficulties he had been trying to get at the bottom of. He had not had the advantage of studying those things from a scientific point of view as much as he would have liked, and possibly he did not take into account sufficiently sulphur, phosphorus and other things; but if they had an iron with high silicon they ought not to get a white fracture. With grey iron the silicon was high, but with white iron the silicon should be low. If it was true that a white iron could sometimes be got with high silicon, he could only say that he thought that ought not to be, because it seemed almost

a contradiction in terms. With regard to annealing, he quite agreed with Mr. Adamson that with a higher temperature they would anneal for a shorter time and with a lower temperature they would anneal for a longer time, and, generally speaking, the longer the annealing the better the result obtained, due regard being had to the class of casting to be annealed. With a lower temperature and a longer time they got a far better result on the lines Mr. Adamson had indicated, and he was quite satisfied that the secret of annealing was time.

MR. HARPER remarked that the majority of malleable founders had to a large extent trusted rather to fracture than to analysis, but during the last five or six months the hematite pigs that had been coming into the works had been gradually going up in sulphur content, until at present there were some pig-irons which it was almost impossible to use for malleable castings. The result was they were either getting burnt stuff or getting it rotten and unable to stand any strains or tests. At the same time, what were they to do when they had either to use that iron or none at all? They had either to shut down or, at any rate, refuse to accept such pigs. When Professor Turner referred to American practice, was it black-heart material he discussed? With regard to the pigs supplied, he had had pigs up to 0.80 sulphur, although twelve months ago it was little more than 0.25. Last month he had some in at 0.60, and at present the material was rather better, the percentage being only 0.40. There were some at present lying in the yard having 0.80, with which they could do nothing whatever.

MR. J. WESTWOOD said that he had found from experience that the higher the temperature at which he poured his metal the better was the casting he got, especially if it had to be machined, and it also assisted in keeping the casting free from blowholes. Out of 100,000 castings he had not had more than 1 per cent. rejects, which he thought was rather a good experience. He also found that if a casting was poured hot he could anneal it for 90 hours at what they called annealing temperature, or somewhere about 950 deg., and get very good results. With regard to the mottled appearance of castings when cast very hot, he had never seen such an appearance in any castings under ¾ of an inch thick, and in that case only at a sharp angle where there might be an extra thickness in the casting. With regard to reject castings, it was quite possible, and in fact easy, to use reject castings up to 8 per cent. of the charge. There ought not to be any selling of soft scrap in any malleable-iron foundry unless there was an exceptional quantity. Any quantity up to 5 per cent. could be used up quite easily, but it was important to use the blast properly. If they were using 14 oz. of blast with two tuyeres just turned away from each other and one tuyere about an inch and a half above the centre of the other, they would work quite all right. He found that by putting the soft casting next to the coke they got better results than by putting it at the top of an ordinary charge. Really, 10 per cent. of scrap could be got rid of in that way.

MR. J. MATTHEWS said that as to the influence of silicon in annealing, he came across a casting 1½ in. in diameter which came out rotten simply because of the slow rate of cooling, which had separated the temper carbon in large blotches. He had overcome that difficulty by adding a small amount of manganese, which made the material stand the impact test. In the casting to which he referred a very light blow was sufficient to break it, but by adding 1 per cent. of manganese the material resisted eight blows and the blotches had entirely disappeared. The carbon was all in the temper form and it was retained through the annealing process instead of being separated out in the free state. He was well aware that a higher temperature was needed in the annealing process when manganese was present. With regard to the analyses of iron coming from the blast furnace, he thought a word ought to be said for the blast-furnace people. Sometimes iron was kept in the pot furnace too long, and in that case the iron got burnt. They could not expect always to get exactly the same analysis from the blast furnace. Also, he had been quite positive that certain castings had been hard and brittle not through any fault in the pig-iron, but because it had been in the pot too long, and that was clearly because of the neglect of the user. In that case there was no fault to be found with the analysis. Undoubtedly Mr. Adamson was right in describing the slow process of annealing as the best. That had often been described by the old masters of the craft as soaking the iron, which was one of the surest ways of getting out the blotches of carbon.

MR. R. BUCHANAN referred to a statement by the author to the effect that "a point of great importance to the malleable ironfounder is that graphite carbon begins to form in the molten iron, and if an iron is melted very hot and held for some time in the molten condition before casting there is a possibility, if the iron is sufficiently hot, of graphite being formed before the molten metal is poured into the casting, which would give a mottled fracture before annealing." He quite agreed with Mr. Adamson that it was possible to get graphite formed in the iron while it was still molten. But it would be more correct if it were said there is a possibility that if the iron is sufficiently *cooled* of graphite being formed before the molten metal has been poured into the casting. The pouring of the metal and the holding of the carbon dissolved within it was largely a matter of the temperature of the metal. If the temperature of the metal was hot it would hold the carbon more strongly dissolved than if it were cooler. Professor Turner had referred to the relationship of silicon to fracture. It was rather significant that the Americans using silicon control produced 100 tons of malleable cast iron to every 6 tons in Great Britain. With regard to silicon control, no doubt Mr. Adamson fully realised what was meant and what was generally understood by the term, and it was rather significant that when he quoted the silicon contents of white irons down to grey that the silicon content increased. With regard to the relationship existing between analysis and fracture, he absolutely disbelieved the view set out by the author until he came into the room. But when he heard Mr. Harper say that he had received malleable pigs containing 0.8 per cent. of sulphur, and they were still white, it was clear that the fracture did not indicate the increase of sulhpur. If they went on adding sulphur, of course they would still remain white. But generally he agreed that analysis and fracture were bound to indicate each other directly. He would like to ask whether Mr. Adamson had had any experience of making malleable castings from pig-irons which were not hematites. He (Mr. Buchanan) heard on good authority that a certain large manufacturer was making castings without hematites. His own view was that if that was done it could only be done by building up, so to speak, the iron, starting with steel scrap and carburising it.

MR. J. SHAW thanked the author for what he considered to be the best and most practical Paper he had read on the subject of malleable iron. He had one fault to find with Mr. Adamson on the question of so-called silicon control. In order to push home his perfectly legitimate contention that silicon control did not exist to the extent that many of its advocates claimed—and certainly its chief sponsor, Professor Turner, never implied—Mr. Adamson rather went to the other extreme. Nevertheless, it was clear that he admitted the exercise of some influence by silicon, as was shown where it was stated that although from the annealing standpoint it might be assumed that large castings should be higher in silicon, the reverse was necessary, to make sure of a white fracture in the casting. He was quite in agreement with the author's remarks in regard to analysis without consideration of fracture. While analysis was one of the best guides a foundryman could have, yet, like silicon control, it was not the panacea for all ills, and must be considered with proper regard to the physical properties of the iron. Take, for example, an over-grey pig—an iron

having often a No. 1 analysis and a No. 3 fracture, which acted exactly as a No. 3 when remelted, both as regards scrap-carrying capacity and fracture. He (Mr. Shaw) last year tabled a specimen with an analysis of G.C. 3.15, C.C. 0.54, S. 0.035, P. 0.44, Mn. 0.97, Si. 0.18. This iron showed an open grey fracture, and on remelting this fracture was maintained, and the whole of the 25 tons of castings were machined all over with no trouble. No foundryman with any knowledge of furnace conditions under-estimated the difficulties of producing regular iron, especially at the present time when so much fine ore was being used. While some foundries might be asking for unreasonable limitations, was there not a lack of candour on the furnaceman's part, say, in sending out iron that was too grey for forge purposes, but made under forge conditions, or iron made when one side of the furnace was blocked, and all the pressure and volume of air was being forced through two or more tuyeres, oxidising the metal and making it unfit for good work, although the analysis might not be too bad? In short, how many furnaces were analysing each cast and tagging on to it not only the analysis, but any exceptional furnace conditions in order to give some idea of the physical conditions as well? That was done by some German furnaces.

The CHAIRMAN said he would like to refer to the diagrams which he himself had specially prepared. (See Figs. 1 and 2.) The tables quoted in the Paper from Charpy and Grenet giving their tests were very

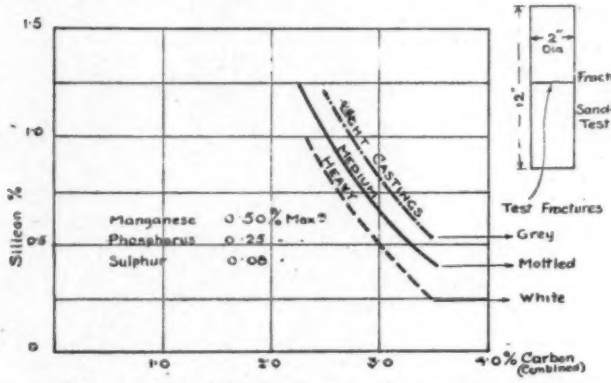

FIG. 1.—BLACK-HEART CASTINGS; RELATION OF COMBINED CARBON TO SILICON.

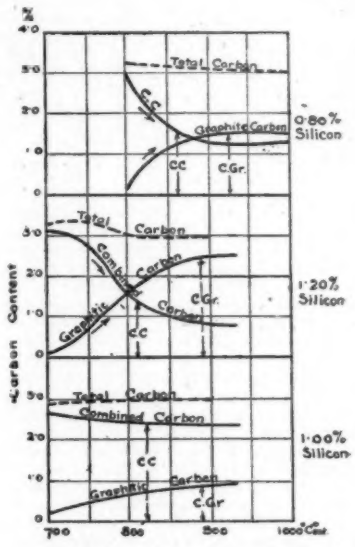

FIG. 2.—CHARPY AND GRENET TESTS ON SILICON-CARBON EQUILIBRIUM.

important, in fact, all-important, to the study of the malleable iron question. It was quite true that figures often misled, but these figures when plotted as curves would show how the experimenters had arrived at some very fundamental facts. The first curve in Fig. 2 showed where Charpy and Grenet used 0.8 per cent. silicon iron, and such a casting would, he (the speaker) supposed, stand for fairly representative malleable practice. The iron was heated gradually at increasing temperatures. The samples were only heated for four hours each, but the principle involved was shown clearly. On arriving at 900 degrees C., as would be seen from the top curve, the combined carbon gradually diminished, whilst the graphitic carbon increased, and gradually the conversion of white iron into grey was brought about. At 870 or 900 degrees Cent. a point was reached when those two conditions of carbon were in equilibrium. In the second test, where they had higher silicon, the same principles were involved. The two carbon curves were seen crossing one another in the region of 800 degrees till they became flat at about the same temperature, as did the 0.8 per cent. Si. iron, namely, 900 degrees. In another case, with a similar iron, 1.0 per cent. Si., it appeared that there the combined carbon was rather high. But again the flat part of the curve started at somewhere about 900 degrees C., where the most critical point was reached, lying at the root of annealing operations of cast iron. This gave the simple and scientific explanation that at about 900 degrees C. in the annealing process the necessary change in the carbon conditions was effected. Mr. Adamson had very correctly referred to those tests by Charpy and Grenet as being of fundamental importance. He had added another curve (Fig. 1) representing American practice, showing how the silicon had a direct relation to the total carbon in malleable cast iron (before annealing). They would observe that there were three curves, the top curve relating to heavy castings and the curve in the centre to medium castings, while the lower had to do with lighter castings. The fractures of these three types of castings were, in the first case, white for the heavy casting, in the second case mottled, while the light casting was of a light grey. These were the results obtained from the breaking of standard test pieces. In that particular works the test pieces were 2 inches in diameter and 12 inches in length. The test-castings were poured in sand, and were allowed to cool for two hours after being taken from the mould; then the test piece was broken across the centre and analysed; the fracture was examined, and for a certain analysis the fracture should give the curves shown.

No doubt Mr. Adamson would agree with him in saying that "black heart" castings were made from irons very much more regular in analysis to begin with than those of which they had any experience in this country; and the Americans were able to get more uniform results than Englishmen obtained from their white-heart castings. British castings were products of irons which varied very considerably in the sulphur content, and that fact, of course, influenced annealing very considerably. He would like to refer to the diagram dealing with annealing temperature. That was a very important diagram, and the curve based on British practice was, he thought, fairly accurate, most annealing being carried out somewhere within those limits. There was a suggestion that he would like to throw out arising from his own experience in connection with heating, and which Mr. Adamson had also hinted at, namely, that longer annealing at a

lower temperature was very important and very beneficial. The cooling curve B in Figure 1 in the Paper showed very plainly the recalescence point B_1 at which a very important change took place, finely-divided or temper carbon separating out at that temperature. Charpy and Grenet showed that at about 900 C. the combined and free carbon attain equilibrium, even in so short a time as four hours' heating. Some American and British workers had, therefore, used this temperature of 900 C. as the primary point to which they heated their castings for some hours, after which they continued the annealing for a long period at about 700 C., with very successful results. The speaker had proved by long experience that the 900 C. point was an important one in the reheating of iron and carbon steels, and in many cases only a short stay at this temperature before dropping to the lower and prolonged temperature heating or annealing had been found necessary to overcome the effects of mass.

Mr. Adamson had pointed out that the lower temperatures were coincident with a low fuel consumption. Those who were engaged in the malleable trade would know very well that, while it was easy to talk about these things, there was a difficulty in keeping anywhere near the theoretical temperature which they knew was the correct thing. The designs of the annealing furnaces were often anything but satisfactory, and to keep those furnaces at a proper temperature was often a difficult practical problem. A great deal of improvement was needed in the design of annealing ovens, and much more attention should be given to that matter. Furnacemen had given most of their attention to furnaces employed upon steel, and the question of annealing ovens for the malleable industry had been very severely left alone. He had seen several ovens at work on castings both light and heavy, and some of which approached the weight which had been mentioned in the discussion. He saw some castings being attempted not far from half a ton in weight, and the castings at the bottom of the annealing furnace must have been some hundreds of degrees different in temperature from those in the top pans. That was a point to which their friends in the malleable trade, and especially those experienced in furnace design, might give their attention.

With regard to the question of sulphur, that was a debatable question, and he thought, with Mr. Adamson, it largely depended on how the sulphur was combined in the molten condition, as some irons were melted at much higher temperatures than others. In that case they might get perfectly white fractures with one iron high in total carbon and low in silicon, and another low in total carbon and high in silicon. They could not work those satisfactorily unless they had very good men able to distinguish between the two. Mr. Adamson had shown that it was not a chemical question alone, because cast iron was a mechanical mixture of chemical constituents. But the difficulty was to know how those various constituents changed. The condition of the manganese sulphide of iron was an all-important one, and that was very much affected by the temperature of the metal in the blast furnace, about which the malleable ironfounder could not be expected to know. Recently it had been found that often the temperatures in the blast-furnace tuyere zone approached 2,500 degrees C., which was not in accordance with usual text-book figures, and it was believed by quite a number of experts that it was nearer 3,000 degrees than 1,500 degrees (the figure usually given. Under these conditions some of the German chemists had sought to prove that the condition of the carbon at those temperatures was absolutely different from anything shown in the text-books, and most likely accounted for some of the mysterious things with which ironfounders and others were troubled. They were very grateful to Mr. Adamson for the facts he had brought before them, which would be of great practical value to the malleable ironfounder.

MR. ADAMSON, in reply, said that as Mr. Cook had referred to the opinion of "scientists," it might be as well to define this term. In the author's opinion, science was knowledge, and a scientist therefore was one who possessed knowledge. As to Mr. Cook's last remark, he was of opinion that the reason why cupola-melted iron was more difficult to anneal than that from Siemens furnaces was on account of the higher sulphur contents of the former.

The author was pleased to have the criticism of Professor Turner, whose valuable work in connection with metallurgy was well known; but before replying in detail he wished to distinguish between science and theory, as there appeared to have been so much misapprehension in regard to these terms in the past. As already stated, he understood science to be "knowledge," whilst theory was after all only "assumption." It was very nice of the Professor to endeavour to bridge the difference of opinion which was known to exist between them, and on his part he respected Professor Turner none the less and had admired the good work he had already done, and was still doing.

First, with regard to sulphur and silicon not being interdependent. If reference were made to the author's exact words *and the context*, it would be seen that he was speaking not of the "academic" application of the term interdependent, but of works practice only. Professor Turner spoke of equilibrium, by which presumably he meant saturation point, which in the case of iron and sulphur was S. 36.66 per cent. He understood the Professor to mean that he had added pure silicon to this alloy, had brought the compound to equilibrium, and had apparently found exactly what was found in works practice, viz., that the highest sulphur was at the top of the sample, as it always was at the top of the pig which contained even *only one-hundredth* of the percentage of the alloy the Professor referred to. The author's statement, however, was based upon the analyses A and B, i.e., of a No. 1 (grey) and a mottled hematite, and he assumed that Professor Turner would be satisfied if it were proved that, in regard to the manufacture of pig-iron, silicon and sulphur were not interdependent. Such proof could be found by comparing the complete analyses and fractures from every cast of a blast furnace working the same ores over any fairly lengthy period, and by taking as a further simple illustration, complete analyses of the highest and lowest silicon irons given in Table I. of the author's Paper on "Temperature Influences of Carbon in Pig-iron."*

Fracture.	T.C.	G C.	C.C.	Si.	S.	P.	Mn.
No. 1 ...	3.14	3.02	0.12	5.85	0.033	0.043	1.00
do. ...	3.28	2.22	1.06	0.35	0.026	0.029	0.07

The author was under the impression that these two analyses of hematite pig-iron—one made on the East Coast and the other on the West—would upset many chemical theories, as (1) the lower the silicon the higher the total carbon, (2) the lower the silicon the higher the sulphur, etc. These two analyses were in no way "faked." Except for carbons they were taken in the ordinary course of works practice, but the particulars given on these two lines of analyses told the practical man exactly under what conditions the two irons were produced.

Professor Turner appeared to have misinterpreted the author's remarks with regard to analysis and fracture. What was stated in the Paper was, "It is physically impossible for a pig-iron maker to produce direct from the furnace absolutely regular grades of iron in fracture or analysis, or both combined," and to emphasise this statement—which was based upon works facts—the author later referred to some laboratory experiments carried out under what are considered ideal conditions, and added, "Even under these ideal conditions *there is no absolute regularity between analysis and fracture.*" Whilst the author admitted it was an unusual phenomenon, nevertheless he *had* met with white iron which contained graphite, and because he observed this he stated what was afterwards proved to be correct, that on remelting in the cupola the iron would be perfectly grey—this was

* Journal of the Iron and Steel Institute, Vol. II., 1911.

however, only apparent to one who had had long experience in "reading" fractures. Here, again, the fracture told the practical man the conditions of the working of the furnace when the iron was made. He agreed with Professor Turner that fracture was not an invariable indication of composition to the ordinary man, but it was possible to form a very rough estimate even of the composition, though, of course, by no means an accurate one. He was glad Professor Turner further agreed with Mr. Cook and himself that a white fracture was more important for malleabilising than composition. The Professor, however, was mistaken in assuming that it was not possible to tell by the eye if sulphur were present, but he was correct in believing that the the *exact* percentage could not be determined without a proper analysis.

The author was not quite clear as to what Professor Turner meant by "border line" iron. Presumably were meant those irons sufficiently "hard," but from which when run into pigs any slight difference in cooling conditions on the pig-beds would produce white, mottled, or grey fractures. Assuming this to be his meaning, Professor Turner was correct in saying that analysis—otherwise silicon contents—did not indicate the fracture, but he was very wide of the truth if he thought any grey-iron analysis—chiefly varying silicon contents—was a fair indication of the fracture, by which he referred to Nos. 1, 2, 3, 4, and 5. It was unnecessary to go beyond the two lines of analyses of No. 1 hematite mentioned immediately above for proof, but such proof *had* been given in several papers. This was getting away from the subject of malleable pig-iron as now used, but as it had a bearing upon the "malleable" pig-irons which could be used in the Siemens furnace the author would deal with the question raised. The author's reading of Professor Turner's remarks was that an open iron—say, a rich No. 1—would be much higher in silicon than a very close-grained iron—sulphur, phosphorus, manganese, etc., being the same. In other words, the iron was open because of high silicon content. Such a belief was entirely opposed to facts, and nothing could be a "scientific fact," if it were opposed to everyday works practice. The two analyses only just quoted above disproved the claim in question, and everyday works experience showed that both open and close fractures of iron were produced which were of, practically speaking, the same chemical composition—in spite of whether the silicon were high or low. As a matter of fact, the conditions under which these two widely different fractures on the same analysis were produced were well known to experienced furnacemen. The practical result of the use of these two fractures of iron for malleable purposes—for they would have to be treated in the Siemens furnace—was that the close-grained iron when it became just white would have a higher silicon than the open iron. The author quite admitted that from the point of view of chemical composition this should not be so, but was faced with the fact that it was so.

As to annealing, he agreed with Professor Turner in effect that the human element largely entered in, and it was in that process where many otherwise good castings were spoiled. Finally, the author thought that Professor Turner had perhaps misunderstood American practice when speaking of cheaper irons. The cheapness of the iron which the Americans used was represented by the difference between charcoal and coke pig-irons, and in the United States they were getting very good results from the latter; but from what the author knew it was very doubtful indeed if any experienced malleable ironfounder in the States would say the results from coke iron were *equal* to charcoal iron. Certainly he would not expect this.

He was glad that one with Mr. Hurst's long, practical experience should be so much in agreement with him, and he hoped the paper and discussion would, as stated, be helpful to workers in the malleable-iron casting industry. In a general way, high silicon meant grey iron, and low silicon white or mottled. For instance, they would not usually expect a white iron to contain silicon 2.00 per cent., or a perfectly grey iron to contain silicon 0.50 per cent., but the great point was that a particular fracture of white or mottled iron did not indicate silicon contents between the limits of, say, 0.25 per cent. or 0.50 per cent. to 0.75 per cent., and 0.75 per cent. to 1.00 per cent., and so on, and that if the malleable ironfounder wanted to work by silicon contents and to have his iron graded by ¼ per cents. he would have to risk taking any fracture which came within these limits. What the author wished to emphasise was that if for the sake of argument silicon 0.40 per cent. usually gave white iron, it did not follow that silicon 0.50 per cent. would be spotted white, 0.60 per cent. hard mottled, 0.70 per cent. medium mottled, 0.80 per cent. soft mottled, and so on; for between silicon 0.40 per cent. and 1.00 per cent. it was quite possible to have all or any of these fractures, even if the sulphur and manganese were constant.

As Mr. Harper had stated, it was unfortunate that foundries were now receiving pigs which were higher in sulphur than usual; but this was difficult to prevent under the conditions of working at the present time. It would be quite possible to mix a small percentage of iron containing even sulphur 0.60 per cent. with a lower sulphur without any very ill-effect, but sulphur 0.80 pr cent. should really never have been sent out. The difficulties in annealing due to high sulphur were fully appreciated by the author, which was why he emphasised the desirability of low-sulphur iron.

With regard to Mr. Westwood's statement that he obtained the best results from metal cast at high temperatures. it might be necessary to add that the question of casting with hot metal depended upon the individual moulder's ability, and also to some extent upon the mixture of sands he used. It was quite true if the metal could be cast hot it would produce a better and sounder casting, etc. He had had that practically demonstrated to him many years ago at one of the largest and most important foundries in Switzerland. It might interest Mr. Westwood to know the theory of this, which was that the higher the temperature of casting, the greater the liability of the metal to "chill" in cooling, and this produced a closer-grained casting. He quite agreed with Mr. Westwood that hot metal would not produce a mottled fracture in a casting under three-quarters of an inch thick.

It was pleasing to find that Mr. Matthews agreed with some of the apparently unorthodox statements made in the paper. Facts such as Mr. Matthews stated could not be contradicted, although frequently when the human element was at fault the iron was blamed. The author agreed in regard to the value of manganese, but a malleable iron with manganese 1.00 per cent. in the casting would be very difficult to anneal, and a better and easier result could be obtained with lower silicon and lower manganese. Mr. Matthews' statement, however, with regard to manganese, confirmed the author's opinion upon its value in malleable castings.

Mr. Buchanan had hardly grasped the significance of the statements which he criticised. For instance, he spoke of the Americans using iron by silicon "control." The author never made any such statement directly or by inference, and Mr. Buchanan showed a lack of appreciation of metallurgy and understanding of melting operations by attempting to draw any such conclusions from the paper. It was quite possible to make malleable castings without hematites, but whether it was *advisable* was another matter. Whether the iron was hematite or not was largely a question of terms, for there was plenty of ore just outside the range of those suitable for hematite. A pig-iron containing, say, phosphorus 0.20 per cent. would be suitable for malleable castings, but he would be sorry for the firm who used common foundry iron containing phosphorus 1.00 per cent. or upwards. It was also possible to use a large percentage of steel, as explained in the paper, but here, again, it was a question of expediency and manipulation, and was dangerous for the average founder.

Acknowledging Mr. Shaw's remarks, the author

said he might have gone further to the opposite extreme in the past in emphasising the value of fracture in order to dispose of the theory so long and insistently advocated by many writers of papers, that only the silicon content of pig-iron mattered, and this question of so-called silicon "control" had obtained such a hold that it became necessary to take a firm stand in opposition. For instance, at a congress of the International Testing Association held in Copenhagen in 1909 a definite proposal was made to this country to grade practically by silicon contents, which the author helped to turn down; but this was followed at the next congress in New York in 1912 by a paper by an Austrian, who endeavoured to prove that silicon alone controlled pig-iron—the old idea of silicon control. At that congress the author gave data which convinced the previous American advocates that silicon control was wrong, and that what the author had been contending for was correct. Perhaps Mr. Shaw knew that the burden and working of the furnace "controlled" not only the fracture—*i.e.*, the carbons—but the silicon contents also, and there were several very large foundries which were now working on carbons, or otherwise by fracture, paying only secondary attention to silicon. The fact that they were right was confirmed by Mr. Shaw's statement that a No. 1 fracture carried more scrap than a No. 3, with which the author was in full agreement. He was very much obliged to Mr. Shaw for having brought forward the fact of the grey iron with silicon 0.18 per cent. remelting grey, as this confirmed statements to the same effect which he (the author) had made years ago, but which were then—and still were—by many absolutely denied. As a matter of fact, it was because he had had this very experience of which Mr. Shaw spoke that he only quite recently at an important conference strongly opposed a proposal to grade malleable pig-iron by silicon contents only, regardless of fracture. It was most unfortunate that there were still men who had considerable influence in foundry circles who could not realise that a perfectly grey iron would remelt grey regardless of silicon content; but unfortunately the theory of silicon control had still a very strong hold amongst those of very limited practical experience in the use of pig-iron. Mr. Shaw's remarks were amongst the most practical he had had in criticisms of his papers.

He was pleased that Mr. Fletcher had grasped Charpey and Grenet's Tables, for his curves showed at a glance the principles underlying the experiments. The author did agree with the Chairman that blackheart castings were made from iron much more regular in analysis—or perhaps to be more correct, in sulphur and manganese contents—than was English malleable. There was no reason, however, why in this country grading should not be more regular if the works carried out Mr. Hurst's suggestion. The author was also glad to have Mr. Fletcher's confirmation in regard to annealing, but before more regular temperatures could be obtained and retained there would have to be some considerable improvement in annealing conditions. He was very much obliged to the Chairman for giving in detail information which confirmed many of the statements he had made from time to time, but which used to be considered incorrect. The author had been frequently amused by misrepresentations of the phrase he had often made use of—"temperature and time"—which the ordinary man had taken to mean the temperature at which the metal left the blast furnace and the time taken in cooling on the pig beds. To meet this phrase "temperature and time," "mass" had been introduced to explain the difference in fracture and analysis, but the Chairman had given the author's real meaning, which was "temperature and time" *inside* the furnace—*which was what controlled the silicon, sulphur, manganese and carbon contents and fracture*, and produced several forms of carbon for which he had contended many years, and had detailed in his last paper before this Institute in 1911, and which was now, according to the Chairman, confirmed by German chemists. Different carbons were produced at different temperatures, and those behaved differently, as shown in the cooling curves published by the author before the Iron and Steel Institute in 1911—followed by publication before this Institute—and confirmed in foundry practice by the statement made by Mr. Shaw, that a No. 1 pig-iron carries more scrap than a No. 3.

The Institute of Metals.

Annual Meeting.

The annual general meeting of the Institute of Metals will be held in the rooms of the Chemical Society, Burlington House, Piccadilly, W.1, on Wednesday, March 13, and Thursday, March 14, 1918. The meeting will commence at 8 p.m. on the 13th, and at 4 p.m. on the 14th, concluding the same evening. The programme on Wednesday includes the report of the Council on the work of the past year, the honorary treasurer's report, election of officers, the induction into the chair of the President-Designate (Professor Carpenter), and the Presidential Address.

On Thursday, at 4 p.m. to 6.30 p.m., a selection of communications (Nos. 1, 2, 3 and 4) will be read in abstract and discussed; and at 8 p.m. to 10 p.m. the meeting will be continued, the Session being opened by the presentation and discussion of Paper No. 5, after which the remainder of the evening will be devoted to a display of kinematographic films of Canadian water power.

The following Communications are expected to be submitted in the order given :—

(1) "The Relationship between Hardness and Constitution in the Copper rich Aluminium-Copper Alloys." By J. Neill Greenwood, M.Sc. (Manchester).

(2) "Aluminium Bronze Die Casting." By H. Whitaker, M.Sc. (Manchester), and H. Rix (Manchester).

(3) "On Grain Size." By G. H. Gulliver, D.Sc. (London).

(4) "Lead-Tin-Antimony Alloys." By Owen Wm. Ellis, M.Sc. (London).

(5) "An Investigation on Unsound Castings of Admiralty Bronze (88 :10 :2) : Its Cause and the Remedy." By Professor H. C. H. Carpenter, M.A., Ph.D., A.R.S.M. (London), and Miss C. F. Elam (London).

THE ELECTRIC FURNACE IN THE FOUNDRY.—Mr. Douglas Walker, of the Booth-Hall Company, of Chicago, in a Paper read at the recent meeting of the American Foundrymen's Association, observed that the common use of the electric furnace in the foundry is for melting down steel scrap for the production of steel castings. The superior qualities of steel castings thus produced, when properly made, has been demonstrated in too many ways for it to be necessary to go into details. According to him the ideal electric furnace should have :—(1) A combination of minimum practical radiating surface and maximum practical depth of refractory material. (2) A minimum number of doors commensurate with speedy and efficient working of the furnace and doors of a type that will work easily and close tightly so as to exclude drafts and prevent loss of heat from the furnace. (3) A minimum number of electrodes entering the furnace and a minimum practical size of electrodes. (4) A minimum power input commensurate with practical operation of the furnace and consequently a maximum speed of melting down. Providing a furnace meets with these fundamental requirements, the further efficiency of the unit depends upon the electrical and mechanical correctness with which the many minor details are carried out.

Work of the Late John Surtees.

At a meeting of the Newcastle and District Branch of the British Foundrymen's Association, on January 26, 1918, the chief subject before the members was a paper on "The Life and Work of the late John Surtees," a Tyneside pioneer of industry to whom it is proposed to erect a lasting and fitting memorial in appreciation of his work on behalf of the foundry industry in the North. The President of the Branch, Mr. W. Mathews, presided.

At the outset, on the proposition of Mr. J. D. Carmichael, seconded by Mr. Edward Smith, a hearty vote of congratulation was passed to Mr. R. Wallis and Mr. Vardy, two members of the Association, upon their creation as Members of the British Empire Order. Mr. Wallis then presented to Mr. J. Young, of Wallsend, the diploma awarded for his paper on "The Control of Cast Iron," read during last session.

Mr. Wallis (Works Manager of the Wallsend Slipway) then read his paper on "The Life and Work of the late John Surtees," in the course of which he said:—

John Surtees' career as a moulder has left an unmistakable mark on the industry, particularly in regard to the Tyne and Wear districts; for to him we owe the introduction of dry-sand moulding as applied to large castings—the general practice in these districts to-day. He was a man of kindly and genial temperament, always ready to help others, and possessed a strong courage of his own convictions. When he conceived the idea of making large marine engine castings in dry sand instead of in loam he did not hesitate in putting those ideas into practice, and made his first large marine engine casting during the year 1868, thereby considerably shortening the time required for such a casting, and producing castings much more correctly to shape and dimensions than by the former methods of moulding.

His appointment as foreman before he reached the age of 30 gives some indication of the thoroughness of his work, his keen interest and ability in the business, readiness to appreciate and adopt new methods, particularly where he saw they could be used to advantage, and a finely developed organising ability. The successful work accomplished and the high reputation attained by the foundries under his management placed him as one of the most prominent figures of his day in the foundry industry of this district, and by means of the men trained by him and transferred to other districts he undoubtedly influenced, to some extent, the industry throughout the country.

John Surtees was born at Albion Row, Ballast Hills, Newcastle-on-Tyne, in 1833; he was educated at Mr. T. Rutherford's school, Byker Bank, and served his apprenticeship as a sand and loam moulder with Messrs. Wright and Brown, Newcastle-on-Tyne, with whom he worked for a short time as a journeyman moulder. Leaving the foundry of his early days he worked as a moulder for Messrs. Hawks, Crawshay & Company, Gateshead; Messrs. I. Joicey & Company, Newcastle; Messrs. Kitson, Thompson & Hewetson, Leeds; and the Airedale Foundry (now Messrs. Kitson & Company), Leeds. In 1862 he moved to Sunderland to take up the position of foreman for Messrs. Close, Burlinson & Company, Millfield Engine Works, having been specially engaged by them for the making of large marine engine castings, they being the first in Sunderland to undertake such work.

In 1865 Messrs. R. Stephenson & Company purchased the iron foundry of Messrs. Wright & Brown, Newcastle-on-Tyne, and John Surtees returned to Newcastle in February of that year as their first foreman, thus returning to control the shop in which he had served his apprenticeship. He continued to occupy this position for 23 years, being responsible for the making of many large and important castings in a highly successful manner, one being the satisfactory casting in 1868 of the first screw propeller moulded in dry sand. He died on April 24, 1888, at the comparatively early age of 55, and was buried in All Saints' Cemetery, Newcastle-on-Tyne, deeply lamented by a large circle of friends, who felt that they had not only lost a valued friend and helper, but one who had left his mark on the foundry and engineering industry; having done something to advance the knowledge, practice, and experience of his day.

So highly was his ability valued and esteemed that he was consulted in the arrangement of foundries other than his own, notably that of the Wallsend Slipway & Engineering Company, Limited. This firm consulted him on the construction and equipment of an iron foundry they were adding to their establishment, and the advice then given was of so far-reaching a nature that this foundry remained practically unchanged until quite recent years. One of John Surtees' workmen was the first foreman of this foundry, and he was followed by another who was also trained by him, and who has only recently retired.

In 1877 John Surtees was engaged by Mr. J. Reid (late Sir J. Ried) as chief of the foundries in the Russian Government Naval Works at Petrograd, but owing to that gentleman's appointment as Chief Constructor of the British Navy this engagement fell through, perhaps to his detriment, but most decidedly to the advantage of Tyneside.

His activities were not wholly confined to the foundry, for the social side of life and the diffusion of the common stock of knowledge had his sympathetic and willing support. When, in 1871, some of the foremen of this district formed the Newcastle and District Association of Formen Engineers and Mechanical Draughtsmen, he was among the founders, and remained one of the most active members up to his death. Frequently taking part in their discussions, he brought his sound, practical knowledge and valuable experience into the debates, much to the benefit and guidance of others. This Association conferred upon him the highest honour they could bestow by electing him their president in 1886. Before his death he wrote a paper on "The Introduction of Dry-Sand Moulding," which, to use his own words, "consist to a great extent of my own experience extending over a period of forty years." This paper, which was written for the Foremen's Association, was fortunately completed, although not read by him, before he passed away. It was read by his son, Mr. R. R. Surtees, before the Association in the theatre of the Literary and Philosophical Society, on November 7, 1888, and by the courtesy of the Council of the Association I am now enabled to read the

greater portion of this paper. It will enable you to understand the work he did in the introduction of dry-sand moulding better than any words of mine. For the illustration of this paper he prepared models of moulds for a marine engine cylinder, and a screw propeller. These models Messrs. R. Stephenson & Company subsequently presented to Armstrong College, and, so far as the writer is aware, are still to be seen there.

Surtees' Paper on Dry-Sand Moulding.

The following is an extract from Mr. Surtees' paper referred to by Mr. Wallis:—

The branch of moulding that I have chosen for the principal part of my subject to-night is of quite a different character from those I have alluded to, and requires the greatest care and skill to carry out successfully. I refer to the making of marine cylinders, condensers, and other large engine castings, either in loam or dry sand. In producing these, the clearest foresight and soundest judgment are necessary; for the operation is no mean or simple one. The foreman and moulder must see clearly through all the stages of the work, for the smallest neglect or error may be fatal to success; in many cases secondary considerations, like after wisdom, are too late. But I wish to draw the attention of my hearers to the great change that has taken place during some years past, in the mode of moulding these large engine castings, and to give an outline as to how it came about. Some years ago, as a practical loam moulder, I found many difficulties in the way of turning out large marine castings as successfully and economically as I could wish.

In the first place, in moulding a marine cylinder, about 70 ins. diameter and 10 tons weight in loam, you require as the base to work from a bottom plate about 8 or 10 tons, and supposing the foundry is fitted up with cranes capable of lifting 30 tons, and with drying stoves large enough to take such moulds, it will be necessary to see that the floor plates are sufficiently strong to carry the weight, for when the cylinder is built up with the bottom cope plate, the binded rings and face plate, with bricks, loam and top plate added, the weight will not be far short of 50 tons. Then there is the labour required to move this weight in and out of the stove, unless you have a tramway and machinery for the purpose. When you have the mould out of the stove to strip or separate the parts, your top part will be lifted first, having snugs corresponding to snugs on the bottom part: through these snugs metal bars about 4½ or 5 ins. square, with key holes cast through each end, are passed from top to bottom, for the purpose of fastening the parts of the mould securely together, and to resist the pressure that takes place when the mould is being filled with metal, this pressure is as the area of surface and height of head. The top part, when lifted, is rested on packings that it may be turned face up, these large top plates have to be cast of best metal; even then they often split when in the drying stove, and have to be strapped and bound with wrought-iron bars and bolts. Having successfully turned the top, the moulders then proceed to fix the pieces in their respective places that have been left down, and then roughly dress up before drying again in the stove. The face plate is then taken down and dressed the same as the top part.

The next part of the work is getting out the boss or body of the cylinder, which is built up to represent the pattern. This having been done, the chest pattern drawn, and the body and mould generally roughly dressed up, you have the cope to lift to get to the bottom flanges; when lifted and rested on stands or blocks, and the bottom of the mould dressed, it is lifted on to the bearing to be returned to the stove for further drying, previous to rubbing up, blackwashing and dressing for good. After being thoroughly dried in the stove, the mould is brought out, then a pit has to be dug in the foundry floor, much larger, of course, than the mould, so as to get the holding down bars wedged up and packed. The mould is lifted into this cast pit in parts, being too heavy to lift after all the pieces are put together.

Another difficulty presents itself with the bottom plate, for be they ever so strong, they generally spring on being moved about on the carriage. Again, I have often seen the body of the mould distorted owing to the binding rings expanding by the heat of the stove, and by moving it from one place to another causing cracks in the mould which mark the castings, and with all your skill you cannot prevent this. Also in putting the mould together, the parts would not fit into their respective places, the guides we had made being far from correct; this caused the moulder to re-fit the parts, by rubbing the joints so as to make them appear level or true, yet in many cases they were far from being right, as it was often found when marked off on the surface table.

This is an outline of the method of moulding a cylinder in loam; of course, the cores of a cylinder, whether made in loam or sand, have to be got up in much about the same way.

Now, my hearers will see that the difficulties I have described were very annoying and sometimes serious; and it became a question with me as to whether they could not be avoided altogether—for some time I have made it my constant study.

About twenty years ago an accident happened at the works of Robert Stephenson & Company, where I am foundry manager, which gave me an opportunity of putting my thoughts into practical shape.

At the time I have mentioned, our firm had in hand several large oscillating marine engines, about 300 n.h.p., for the London and North-Western Railway. In erecting one of these engines, when lifting the entablature, a casting in two parts of 18 tons, into its place on the top of the columns, the chain broke, and the castings falling, they were broken also.

The question then arose, how to replace them in the shortest possible time, the date of delivery being fixed, after being pressed by our late manager to get them early. I then resolved to make them in dry sand, and dug a pit in the foundry floor after the system of the Midland counties.

This caused some sensation amongst our loam work moulders, the system of the shop and the district of North-East Coast being to mould them in loam. The sand moulders were quite delighted at having the opportunity of experimenting, and set to work in earnest to let the proud loam moulders see what they could do, the loam moulder being a gentleman considering himself of a higher grade than his brother of the sand end. However, we got them cast within the fortnight, with very little overtime, and a fair job. But this being the first attempt, we found something was required to make the castings really first class,

with the drying the coal dust being burnt out of the sand; the metal rutted into the sand about the heavy parts, which had a rough appearance, so in the next we ground the sand in a mill and blackwashed the heavy parts, and when cast they proved to be far beyond our expectations. The next one we made, being blackwashed in every part, turned out clean, very sharp, and much freer from creases and marks than our loam castings. My employers being quite satisfied with the results, they gave me permission to try the same system with the marine bed plates which we had in hand, and were moulding them in loam for Lamport & Holt, of Liverpool; large single crank engines; the beds weighing from 12 to 17 tons, But not having a stove large enough to take the mould in, nor yet a crane to lift such a heavy mould, we were obliged to make a pit in the floor and mould them there, drying them with fires on the bottom of the pit around the sides of the mould. This, of course, was a very expensive system.

Having many faithful workmen willing to carry out the instructions given, and deserving success, we made the bed plates off the old loam patterns, and they turned out well, in fact, better than we had anticipated. At this stage I had a sand mill made to grind all the sand.

These bed-plate patterns being all in one piece were very difficult to draw out of the sand. This forced the question of having the patterns made in parts, and with the sanction of our manager, for the next order of marine engines, we had them made with the bearings loose, with dovetails at ends, the counterparts being fixed to the side pieces. This proved to be a handy and convenient way, both for the moulder and the pattern maker, and from this beginning, which soon became known to the trade, all bed plate patterns of that class were made on that principle. After this we gave our attention to the condenser, for which we put in special boxes or tanks in the floor, provided with strong lugs on the sides, and beams or bars to reach across for holding down with strong bolts.

This system is very handy and thoroughly reliable, and is adopted for all castings that are made in dry-sand pits. Condensers from 10 to 17 tons have turned out well.

After this we got up a box for the screw propeller because those we were making in loam had unsightly marks along the blades, owing to the blades springing with the heat. I may say that I had more trouble over this with some of our loam moulders than all I had done before. One of my best workmen, when asked to take part in moulding it, put on his coat and left the place rather than be identified with work that he said was certain to be a failure. However, there was one faithful workman, a sand moulder, who stuck to me like a brother, he making the plates and boxes required from templates and sketches that I had prepared. This moulder, R. Warburton, who departed this life some 15 years ago, and two other faithful workmen, who are still living and working for the same firm, W. Gardner and R. Parker, cast the first screw, 17 ft. diameter, and about 6 tons weight, when turned out proved to be one of the finest castings we had made up to that date.

The screw box cost £7 for labour, the moulder having time-and-a-half when making it. This was little more than a set of loam plates would cost for a 17-ft. screw. Then there was the saving of 2,000 bricks as well. We next gave our attention to the marine cylinder, having received an order for a large h.p. cylinder, 13 tons weight, for the s.s. *Durban*, for duplicate, from R. & W. Hawthorn & Company, and this was before we had our boxes and tackle got up mechanically; this was a job detaining the steamer, and had to be pushed. This, you will understand, caused me much anxiety, being a costly job to experiment on; however, we cast it within three weeks, and it turned out a clean, fine-skinned casting.

We have cast in dry sand all the various types of marine cylinders up to the present day. Compound with the two cylinders cast in one; next, the triple expansion, with the high and intermediate cast in one; with single slide chests, also with double slide chests, and others with single piston valve casings and with double piston valve casings.

We are also making locomotive cylinders in pairs, and compound on the same principle with good results.

During this time R. Stephenson & Company have trained many moulders to this system of moulding, having supplied about twenty young men to various leading foundries in this district and other parts of the South of England, and to works abroad as foremen; many of whom are doing well, and perhaps some are in this room to-night who can bear testimony to what I have said. This system is now at work in all the leading works on the North-East Coast with the exception of one, I believe, and in other parts of the country; this fact speaks for itself. Another great good it has done by bringing about a better feeling between the two classes of moulders, and instead of injuring the loam moulder, it has further developed his branch, for the system is such that the two branches blend together, and many loam moulders with us can work at dry sand with great success.

Again, we have a great advantage with patterns; you may use them over and over again and they will retain their original form, which is a saving to the engineer. The patterns that are used in loam moulding with the heat in drying and the wet loam the first time they are used, get so distorted that you cannot find a straight line about them, the moulds having to be rubbed into shape and depend entirely upon the mechanical eye of the moulder.

Surtees Memorial.

Beyond the memorial stone at his grave and a curb placed there by the Newcastle and District Association of Foremen Engineers, and his paper in their Transactions, concluded Mr. Wallis, no permanent record exists of the work John Surtees did for the foundry industry. This should be remedied, and this Association is a body peculiarly fitted to undertake the establishment of a permanent and lasting memorial to one who in his life time, counted among his friends many who then, and even now, are men holding prominent positions in the foundry industry.

It has been suggested as a fitting memorial the establishment of a Scholarship at, say, Armstrong College, open to those employed in foundry work. Mr. Mayer, of Dumbarton, Past-President of this Association, has offered to open the subscription list with £25, and other sums have been promised.

To establish a scholarship worthy of the man it is to commemorate, something like £1,500 will be required, and there should be no difficulty in raising such an amount for such a worthy cause.

The Care of Pattern-Shop Machines.

By JAMES EDGAR.

In the average pattern-shop the machines are not properly cared for. Very often a man is expected to sharpen the saws and planing-machine knives without allowing this extra work to interfere much with his ordinary bench work. The consequence is, that unless the foreman has a good deal of time free from checking finished work, and can keep a close eye on the machines, they are misused and carelessly used, and thus are seldom in a satisfactory condition. A great deal of wasted time is thus involved, because unless wood-working machines are in excellent condition they are inaccurate, and leave so rough a surface on the timber that a great deal of hand finishing is necessary. It should never be necessary for the pattern-maker to plane wood that has been over a planing machine, nor to touch half-laps that have been cut at the circular saw. There is no reason why timber worked at a machine should not be as well finished as timber worked at the bench. In some pattern-shops it is the practice not to allow apprentices to use the machines until they are in the last year of their apprenticeship, and it is a wise provision. Apart from the danger to the lads and the lessening of their value as skilled craftsmen, by curtailing their opportunities of mastering the bench tools, it is generally admitted that more damage is done to the machines by a few boys than by a score of men.

The difference between the conditions of the machines in the metal-shops and the pattern-shop is very noticeable. In the metal-shops the machinist is a specialist, and as he is usually on piece work, it is in his own interest to keep the machine running smoothly and in perfect order. In the pattern-shop, however, machine work is subsidiary to hand work—a man uses a machine for a few minutes and goes away. The consequence is that the care of the machines is nobody's business. It is a very small shop indeed where a qualified wood machinist would not pay, and in a larger shop, where the man's time would be fully occupied sharpening and repairing belts, there ought to be a handyman whose duties would be chiefly to attend to oiling and cleaning.

There is so much dust and sawdust in the pattern-shop that the lathes, and indeed all the machines, get out of truth unless they are kept clean. The foreman should insist on the machines being oiled first thing in the morning, and it is better that this be done before the machinery is started at all. It is not possible, of course, to clean them thoroughly every day, but it ought to be done at least once a week, even if it means stopping the machinery for an hour or two on Saturday morning.

The lathes are usually the most neglected machines. As the machinist does not do any turning even he forgets about the lathes. If the caps are left off the oil cups, they soon fill with dust, which gets into the journals and grinds, the consequence being that it is not possible to turn work true. Wood-turning lathes run so fast that they are more liable to heat than metal lathes, but the greatest damage is done to the lathe, especially the smaller lathes, by hammering on the centres and the faceplate. It is much easier and better to tap the centres on the ends of the job before it is put into the lathe at all, and the foreman should insist on this. It is an equally simple matter before screwing on the chuck to cut a washer from sandpaper and put it behind the chuck. If this is done it will always unscrew. Far better than than hammering the chuck is the method of heating the screw with a gas flame. This expands the chuck sufficiently to loosen it.

The work for both the circular saw and bandsaw in a pattern-shop is comparatively light, and the saws should be easily kept in order. Unfortunately nails are occasionally forgotten, and they play havoc with the saw teeth. It is a very easy matter to twist a circular saw and almost as easy to put it right. The packing should press close on the saw, and if a stick is pressed against the saw and held steady the saw will again run true. It is a great mistake to rip a board for half its length and then reverse it. It ought to be pushed right through. Reversing timber not only damages the saw, but it invariably loosens the packing. It is wise to have a small shelf in front of the saw-table for a forked stick with which to push the wood. Workmen will use the stick when it is there, but they will not make it, and most of the accidents at circular saws are caused by using the finger for pushing the wood when ripping.

Bandsaws are often changed when they are not really blunt but dirty, and they should be cleaned with paraffin without being taken off. A well-kept bandsaw is the most valuable tool in the pattern-shop. There is much difference of opinion as to the correct tension of the saw. A slack saw will not break, but it cannot be relied upon to take a deep square cut. There is nothing more annoying than to have a piece of work undercut at the saw through it being too slack, or the block in the table not guiding it properly. Saws last longer if the rubber on the wheels is kept clean and free from sawdust.

The most sensitive machine is the planer. A grain of sand on the wood spoils its usefulness, and the only way of obviating this risk is to cut off the dirty ends of the timber before it is planed. The surfaces of the timber should be well scrubbed with a wire brush to get off any dirt. The precaution of sawing off dirty ends is also necessary before finishing at the trimmer.

Nearly all pattern-shops now have a sandpapering disc and rollers. They are great labour savers, and one sheet of garnet paper will keep a shop of fifty men going for a week. The paper is too often spoilt by grinding end grain on it, and consequently burning it. The writer has tried the device of washing the paper on the disc, and also of dry brushing it when its gets clogged, but neither way is very effective. Generally speaking, when the paper is clogged it is done. Washing it may make it last a day longer, but the water injures the gearing for adjusting the table, no matter how much care is taken to dry it up and oil.

In every pattern-shop, however small, there should be a set of emery wheels for grinding gouges and a good soft grindstone. Nothing accelerates work as much as sharp tools, and nothing induces men to work with blunt tools as much as an uneven or very hard stone. The grindstone should be trued periodically and regularly.

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British Foundrymen's Association.

LANCASHIRE BRANCH

Melting Copper Alloys.

This Paper, by Mr. H. L. Reason (see our last issue), was discussed at a meeting of the Lancashire Branch on Jan. 12. Mr. R. Onions in the chair.

THE CHAIRMAN, in opening the discussion, said Mr. Reason had referred to a problem which was growing in importance in the district he came from, and also in the Manchester area, viz., the best method of dealing with cuttings, borings and turnings, composed of manganese bronze and other non-ferrous metals, which were now produced in quantities exceeding anything previously known. They could not be used in the shops which produced them; even when it was sought to utilise them in castings there was great trouble and difficulty. Any light which Mr. Reason could throw upon the problem would be valuable. Taking aluminium, for instance, it was often used in the machine shops with some cutting compound, but if it got matted together it lost much of its value. Something had been done in the way of briquetting. He produced for examination a specimen made from very small chippings of manganese bronze which had been placed in a die under a heavy hammer and struck a few blows. The pressure was 36 tons per sq. in. What was wanted was some means of squeezing these things into a solid mass, and the results of a series of tests at varying pressures showed that it must be somewhere in the neighbourhood of 20 tons per sq. in. in order to hold the stuff together.

There was another point on which he would like some information. In connection with the light type of engine now made so largely, the question arose of running white metal into the bearings. There were certain reducers which were only suitable for higher temperatures, such temperatures as would be employed with a white metal containing 80 per cent. tin with some copper and lead. Generally the melting temperature of the mixture was about 400 deg. C. to 500 deg. C. What information could Mr. Reason give about this subject? What took place in the metal that was in the bottom of the pot? They might use freely the stuff off the top, but when they got near the bottom, they could feel with a rod that the mixture was in a plastic condition; was it desirable to keep such metal in a fluid condition over such a long period? Not much of it was required in the finished bearings, perhaps a few ounces, but if it was not done properly the engine would be practically wrecked and its sphere of usefulness destroyed, the matter was of great importance. If the metal was overheated it was useless.

MR. W. H. COOK said during the last 3½ years his firm had had practical experience of the question which Mr. Reason had brought before the members. They used an electric furnace of the type described; it had been very successful, and they were prepared to deal with manganese bronze if anyone would sell it to them. They bought from one firm manganese bronze swarf to melt and make into castings which had to stand 28 tons tensile. That firm was buying castings made from the new metal at 2s. 3d. per lb., of which 70 per cent. proved to be unsuitable when the machining had got half way through, or perhaps more, owing to the sponginess. They mentioned this to him, and he supplied them with good, sound castings made from the bronze swarf. This was first melted down into ingots, and then to every 100 lbs. 1½ to 2 oz. of phosphor tin was added when the metal was in the crucible for running into the mould. It seemed to have an effect very similar to thermit. If the stuff was as "dead as ditchwater" it would boil up when that was put in. They had made 6,000 castings and not 1 per cent. were bad. They were only ⅛ in. thick and had to stand 500 lbs. per sq. in. For some purposes his firm used new metal. If they were asked to give a phosphor bronze to stand 18 tons tensile and not more than 5 per cent. elongation, they could get that with new metal, using right percentage of phosphorus, but if the swarf from those castings was remelted the elongation would increase to, say, 17 per cent., and, after a further remelting, to 24 per cent. That seemed to be the effect with all swarf. He attributed it to the volatilisation of the phosphorus, which decreased with each remelting.

He knew where briquettes were made with a pressure of 9 tons. The price of the machine was £800 or £900, and a firm which was not using big quantities would hesitate to lay out that sum. They made a machine themselves in which the pressure was 36 tons, and it pressed a charge of 30 lbs. into a bloom 6 in. diameter and 8 in. or 9 in. long. Anyone who had to do with the melting of this loose swarf would know that the men objected very much to charging the furnace with it; it cut their hands and they could not get anything like the output they wanted. The stuff was bought from the Government. In drying it lost 4 per cent., for which they claimed, and after that the melting loss was 13 per cent. After briquetting the loss was reduced to 6 per cent. He had heard people say that solid briquettes lost 2 or 3 per cent., and others say that they could melt brass at 2½ per cent. loss, but he could not do it. The whole secret of producing good, sound castings was temperature. Whatever mixing was made, temperature governed everything.

MR. HOGG asked what Mr. Reason thought would best prevent the shrinkage of castings.

MR. CARTER said one thing that was detrimental to the life of the gas-fired furnace, one of its defects, was the spilling of metal from the crucible into the furnace. If they employed a man who was extremely careful not to let any metal go off the top and down the side of the lining, then he thought it would be a great success. The metal going down the furnace would score a line all the way down and accumulate at the bottom. If the stand, instead of being horizontal, was perhaps at an angle of 45, or leaning against the side of the furnace, or was perhaps propped up with a piece of fireclay or broken pot, the man then spilled more metal and it became worse. His firm had used a small furnace for some time. When the lining got scored like that they simply chipped it out and put in a plug. They had very little trouble with that.

MR. REYNOLDS asked about the use of phosphorus as a flux for copper; how it was prepared and introduced into the copper?

MR. H. SHERBURN said the authors of papers seemed to have different opinions about fluxes. Could Mr. Reason assist them about the use of charcoal? It had been pointed out to him that

being woody it was apt to be suspended in the metal; there was a difficulty at times in getting it clear, and one was likely to see it in the casting.

MR. LANGTON said he did not look upon charcoal as a flux. It semed to be thrown on the top of the pot and came off in sparks. In his opinion the best flux was ordinary coal. If they threw coal on the top of the pot and stirred it well it acted as a flux to the metal and then it did the same thing that charcoal did after it had burned away; it provided a sort of covering on the top which prevented oxidation. There was no doubt small coal was an excellent flux for bronze and brass.

MR. CORDINGLEY remarked that he had found different brands of copper gave different results.

MR. REASON said Mr. Onions had referred to trouble in melting manganese-bronze which did not occur when gunmetal was used. He attributed that to the chemical analysis of the borings becoming different. When melting brass or bronze the greatest percentage of the melting loss took place in the zinc content. Whether the fracture described by Mr. Onions would have been prevented by using phosphorus he could not say; it would have done no harm, and he thought it would do good. Where the metal did not give the same result when used for turning, it was always advisable to try to bring the swarf back to its original mixture. As to briquetting, if the facts were as Mr. Cook stated, and the loss could be reduced to 6 per cent., it would evidently pay to put in a briquetting plant, but the cost was considerable. There was a good deal they all wanted to know about white metals, casting temperatures, tensile values, and so forth. When using a white metal with a lead base it would be necessary to keep the metal well stirred before pouring. Mr. Cook's statement that he had no trouble with manganese bronze was explained by his addition of the phosphor tin. When the metal was remelted two or three times the elongation went up. That bore out the suggestion that as the zinc was lost and the alloy became richer in copper they got an increased elongation. It was interesting to know that Mr. Cook had considered the effect of temperature on casting and that his figures agreed with those in the paper. If brass founders would give this subject more attention they would be amply repaid.

The shrinkage in castings was a very wide question. Before they could advise what was the best thing to be done they wanted to know the time of casting, where the shrinkage occurred and what alloy was used. All those points had a bearing upon the problem. In a very difficult casting of uneven thickness the trouble of shrinkage had been overcome by using chills; it could also be overcome by gating where there was not such a striking difference between the sections of the metal. A good many shrinkage troubles were attributed to the casting temperature. Phosphorus was added to copper in the form of phosphor bronze.

Fluxes were not used to any extent in brass foundries where gunmetals were cast. If they had to deal wth metals of indifferent character or to purify the metal they would use a flux according to the purification required. Mr. Langton fell into an error when he described coal as a flux. A flux was something which entered into the metal and threw out the gases therefrom. Coal and charcoal simply formed a protective cover on the top of the metal which prevented the metal absorbing oxygen and forming oxides. Coal was all right, but as it burned away it left ash. Charcoal one could leave much longer; it would be found more efficient if used in small granulated form, not in too large a form. Incidentally it mixed with the slag and helped to clear the top of the metal.

To obtain the best results in a brass foundry it was necessary to watch the brands of copper bought. It was always advisable to buy well-known, recognised brands which contained the minimum amount of impurity. If they bought without any record, buying "best-selected" copper without reference to brand or anything, but simply accepting what was sent in, they might run along all right for a time, but one day the sellers would send in an indifferent brand and there would be trouble. In these days, when we were working more upon the specification of physical properties than upon the alloy, it was necessary to know that the virgin metals were somewhere near the standard quality. In passing, he would say that it was surprising how pure virgin metals were.

With regard to the sand that was used to produce fine castings, it was obtained in and around Birmingham; it was very similar to what was known as the Mansfield sand. They also mixed and used as a facing what was known in Birmingham as a loam sand. It was of a fine silky nature. They mixed it with plumbago.

LONDON BRANCH.

A meeting of the London Branch of the British Foundrymen's Association was held at the Cannon Street Hotel, on Friday, December 14, Mr. T. W. Aitken in the chair.

The diploma of the Branch was presented to Mr. James Gaunt for the best paper read during last session, the recipient suitably acknowledging it.

Foundry Facings and Refractories.

Mr. H. Winterton, of Birmingham, then read a paper on "Refractories and Foundry Facings." This paper appeared in our issue of May, 1917 (see page 263, vol. 19).

MR. W. ELLIS asked for a rough and ready method of testing facings, and also enquired if it were possible to make a facing without all the bad ingredients which the author had referred to.

MR. W. H. ASTON, referring to the author's mention of superfine-coal, and fine, medium and course, asked how these were to be defined. What was a good superfine coal, which he had described as being required for different classes of work? At present they bought ground coal and plumbago without any very scientific investigation, and there was no simple, practical means of testing these facings in order to know beforehand whether they would give the result desired. At present, the only test was in the mould.

MR. WINTERTON said that strictly there was no mineral charcoal. There was animal or wood charcoal, but so-called mineral charcoal would not burn. The mineral facings which were now made did not contain a large proportion of wood or animal charcoal. They were made partly of carbon and partly of one or two other ingredients. With regard to heavy blacking, it was easy to test. If it were put into water and it went to the bottom it

would not make a refractory for a mould, and if such a blacking were used it would certainly scab. To test the grists was a matter of eyesight and a small sieve; but the strength of coal could only be tested by the heat test. It must either be chemically analysed or tested in the fire. The percentage of ash should be about 12 per cent. or even 14 per cent. The analysis of a good coal was 12 per cent. ash, 37 per cent. volatiles, and 51 per cent. fixed carbon. Castings made in moulds dressed with that coal had the particular blue colour beloved of moulders, and the stripping process was very greatly simplified. At the present time an endeavour was being made to institute standards for grists, in order that founders in this country might be able to specify a particular standard, and be able to get it. The same remark applied to blackings.

Mr. Bartlett, referring to the mixing of facing sands, said he had found that whereas the result with a flat casting was quite satisfactory, with a casting of another shape, using the same sand, it was found that a certain amount of coal dust ran down. That was the case with a conical casting and also with a pulley. He had found ways and means of getting over these difficulties, but he would like Mr. Winterton's opinion. The result was veins on the top surface of the casting. Was that through excess of ash or any other ingredient that should not be present, or was it simply a question of the shape of the mould and the casting?

Mr. Winterton said he thought that the shape of the casting was entirely responsible for the difference in the action of the coal dust on the various parts. There would, of course, be a difference in the thickness of the casting, and therefore a difference in the amount of heat imparted by iron when it was poured. At the same time it was possible that the coal dust used by Mr. Bartlett was high in ash, because even though the heat was applied in a greater degree than in a flat casting, a coal sufficiently low in ash should resist the tendency referred to.

Mr. Bartlett said he got a good result by using less coal dust. He was referring to the same thickness of casting in the two cases.

Mr. Winterton said he had come across similar complaints in hollow ware, and the difficulty there had been got over by a decrease in the carbon facing in order to stop it running.

Mr. Bartlett said he thought it was the shape of the casting that was responsible for what happened.

Mr. Winterton, speaking with regard to plumbago, said he had mentioned in the paper that was really a matter of carbon content. Plumbago was imported from the Ural mountains and from Ceylon. There were also forms of graphite which, however, did not resist the heat, when placed in the mould, to the same degree as plumbago did. These graphitic forms were imported from Spain, and they reached this country in various degrees of purity. There were three groups, viz., plumbago in the highest form, graphite and blacklead. The latter was imported from Spain, and before the war from Germany and Austria. The best of the three was plumbago, and the purer it could be obtained, the better the results. He had not, however, any analyses.

Mr. W. H. Aston said the difficulty was to know how to test for purity.

Mr. Winterton said it was necessary to go to the laboratory for this. It was, however, possible to tell roughly by the feel of it, but that came from experience. The water test was good up to a point, but it would be impossible to ascertain the carbon content from the water test. Colour was also a test, although it did not necessarily follow. He had seen excellent plumbago of a very dark colour, and he had seen light coloured plumbago turn out poor stuff in a laboratory test, and also in practice. It would not go through a sieve in the same way as coal dust, owing to its clinging character.

Mr. James Gaunt asked if the author had had any experience of substituting charcoal for superfine coal in light casting facings; also how far did he consider it advisable to carry the grinding of sands for use in light work. Some firms used ground sand for castings up to 1 cwt., and others on work up to 20 tons. Perhaps it was a matter of districts. As a rule the heavier green sands for castings were mechanically mixed and not ground. What was the author's experience with the heaviest casting for which the sand should be ground before use? Reverting to the question of the coal dust running down, he thought it was due to some extent to the surface of the mould not being covered quickly enough. With a flat plate, the surface was covered right away, but with a shaped article or anything with a deep lift the mould filled gradually. Theoretically, during the time the mould was filling, the coal dust was being coked, and was swelling in the mould, and the marks on the top sides of the casting were due to some extent to sand displaced by the evolution of the volatile gases and the swelling of the coal dust.

Mr. Winterton, replying on the point regarding charcoal substituting coal dust, said the firms he had mentioned in the Paper were using special mixtures which had been substituted for coal dust to a great extent. In these mixtures a certain proportion of the superfine coal was eliminated and a certain proportion of charcoal was substituted with other ingredients. At the same time, it was more expensive. As to grinding sands, he had seen very many practices in this matter, and he was inclined to agree with Mr. Gaunt that it was a matter of districts. Many foundries ground their sand for light castings, and just mixed them for the heavier ones. He had never come across a case where the proportion of coal dust was increased because of grinding. He could not altogether agree with Mr. Gaunt's theory as to the running marks, because in his experience they had always been regular. If Mr. Gaunt's theory was correct, they would not be.

Mr. Bartlett said that in a cone-shaped casting the lines ran vertically to the centre. In a pulley they were in regular radius lines round the pulley. He thought the shape of the casting was the cause.

The Chairman said he thought the lines were formed chiefly by the gases at the bottom of the mould being forced upwards and not getting away as fast as the molten metal was driven up through the mould. With regard to grading coal dust, a useful contrivance consisted of four sieves about 5 in. square, one above the other, and of different meshes. In this way it was a simple matter to test the grade of the coal dust or sand.

Mr. H. G. Barrett, referring to plumbago, said he placed some in a bottle with water. It was sometimes found that whilst it was black on the upper surface, there was a gradation of colour,

until at the bottom the colour was that of rusty iron.

Mr. Winterton said that the iron colour was due to iron oxides, which certainly were not desirable in any form of refractory. He had always found that the best qualities of plumbago were uniform in colour.

Mr. Bartlett said he had put charcoal blacking in facing sands time after time with heavy castings when he thought ordinary coal dust was not going to be satisfactory as a heat resister.

Mr. Gaunt said that in some light castings of a special alloy in the moulds for which charcoal was used, it was found to eat into the skin of the mould. He got over it by dusting the mould first with silica flour, and that gave a beautiful casting with a smooth skin.

Mr. Stone said an old-fashioned practice was to pulverise a piece of soft gas coke and mix it with resin. If the mould were dusted over with that it gave a splendid skin to the casting.

The Chairman asked if anyone had had experience of what was called stamping. That was a process for very fine work; he had made castings on the process which it was difficult to see were made in sand, so smooth was the surface. In this process blacking was shaken over the mould when the plate was drawn. The plate was then warmed and put back again. The surface of the mould then consisted entirely of blacking, and it gave a splendid casting; but it was not a commercial proposition at all.

SCOTTISH BRANCH.

At a meeting of the Scottish Branch of the Association, held at Glasgow on February 9, Mr. Matthew Riddell (Branch President), who occupied the chair, intimated that negotiations were being instituted to try and bring a closer relationship between the technical societies in the West of Scotland, and he hoped as a result from those negotiations that the usefulness of these Associations would be extended.

The President then called upon Mr. C. H. Desch, D.Sc., D.Ph., F.I.C., to deliver an address on "Carbon in Iron." Dr. Desch at the outset stated that he would introduce his subject by assuming that cast iron consisted of an alloy of two constituents, namely, iron and carbon, and proceeded to explain with the aid of a freezing point, or equilibrium diagram, the various changes which took place during the solidification of such an alloy.

Within the last few years a great amount of scientific knowledge had been acquired regarding iron and steel, but there still remained a large field for research. He believed that much of the information which was still required to bring many of these investigations to a successful conclusion might be obtained by a closer relationshhip being established between the practical workman and the scientist.

The study of the phenomena of solidification was of great interest to foundrymen, and the benefits to be derived from such a study would be far-reaching in their effect. After considering the different conditions and changes which took place on the solidification of an alloy consisting of iron and carbon, the lecturer proceeded to explain how the other constituents found in cast iron, such as silicon, phosphorus, and manganese, acted on the carbon and incidentally on the strength of the material.

If iron consisted of an alloy of iron and carbon only we might have a metal of an excellent quality, because the scientific control of iron depended entirely on the shape and mass in which the carbon was found. When large flakes of graphite were found in iron, it was detrimental to its strength.

The lecturer explained that the constituent next in importance to carbon was silicon, because of its influence on the carbon. Silicon favoured the formation of graphite and retarded the formation of cementite. It also tended to break up the cementite, and this effect determined the importance of the influence of silcon.

LANCASHIRE BRANCH.

Visit to Works of Spencer & Cook, Limited.

Between 50 and 60 members of the Lancashire Branch paid a visit to the works of Messrs. Spencer & Cook, Limited, brassfounders, Stalybridge, on Saturday, February 9. The visitors, who were welcomed by Mr. Cook, were taken in parties through the principal sections of the works, and the various operations were explained to them, practical illustrations being given in many instances. Two most ingenious machines, patented by the firm, and which are supplied in large quantities to the War Office, excited the keenest interest, and were evidently quite new to the majority if not to all the members present. The first was a machine for reducing tin cans used for meats, fruits, fish and other commodities, of which vast numbers naturally accumulate at the Front. About 40 of the cans, some of them of considerable size, were placed in an iron trough, and in a very few minutes were compressed into a solid block some 18 in. square. So thoroughly was the work done that the block needed no packing, and could indeed be thrown about without fear of any of the pieces coming away. The other patent was a filtering cart, the cylinder of which was capable of holding 110 gallons. This quantity could be pumped in by an apparatus attached to the rear of the cart, in a quarter of an hour, and was so effectually cleansed and purified by the disinfectants and other means employed, that when drawn off it looked and tasted like the purest town water supplied for domestic purposes. The visit proved pleasant and agreeable to everyone, and a hearty vote of thanks was carried to Messrs. Spencer & Cook for their invitation and courteous reception.

Annual Meeting.

Mr. A. Key presided over the monthly meeting held on Saturday, February 2, at the Manchester School of Technology.

The Chairman said it gave him very great pleasure to present to Mr. Allen Hill the diploma awarded by the Literary Committee for his Paper, read during last session, on "Plaster Matches."

Mr. J. Shaw, of Dudley, gave an address on "Loam Moulding and its Various Applications," illustrated by a long series of lantern slides, which he described in a conversational manner. As against the general idea that loam work is always costly, he maintained that it saved pattern-making where only one or two castings were needed, and that it was cheaper when the shape could be easily struck up as well as in the case of special rigs and in various jobs transferred to loam from sand, while it was safer when the casting was large and intricate.—The attention of members was called to a Paper on "Loam Moulding" in last year's proceedings.

Trade Talk.

In the House of Lords, on February 4, the Non-Ferrous Metals Industry Bill was read a third time and passed.

THE BRYAN DONKIN COMPANY, LIMITED, of Chesterfield, have removed their London offices to 3, Victoria Street, Westminster, S.W.1.

AT a meeting of the Birmingham Metallurgical Society, Mr. Thomas Vickers read a paper upon "Works Practice in Case Hardening."

THE MINISTRY OF MUNITIONS have brought rosin and rosin oil under control, and in future dealings are restricted to those covered by licence.

THE BRITISH AUTOGENOUS WELDING COMPANY, LIMITED, are being wound up voluntarily, with Mr. L. M. FOX, the secretary of the company, as liquidator.

CAMMELL, LAIRD & COMPANY, LIMITED, of Birkenhead, have acquired the Barton Estate, Rock Ferry, the area of which is between twenty and thirty acres.

MESSRS. C. DOLPHENS AND G. VALCKE, Beverley Engineering Works, Willow Avenue, Barnes, trading under the style of Valcke and Dolphens, have dissolved partnership.

MESSRS. W. V. STELFOX and J. W. Adams, engineers and iron moulders, trading under the style of the Coton Foundry Company, Chilvers Coton, have dissolved partnership.

MESSRS. M. BIDERMAN AND W. J. MEDDINGS, trading under the style of the Emm Bee Engineering Company, Alliance Mills, Windus Road, Stamford Hill, have dissolved partnership.

MESSRS. MARTIN BROTHERS, machinery merchants, of Manchester, have been fined £250 and 100 guineas costs for dealing in tools without the sanction of the Ministry of Munitions.

T. W. BROADBENT, LIMITED, Victoria Electrical Works, Huddersfield, have appointed Mr. J. Espie, of 36 to 38, Smith Street, Kinning Park, Glasgow, as their agent in Scotland.

THE GOLDENDALE IRON COMPANY, LIMITED, of Tunstall, Stoke-on-Trent, have been compelled to blow out their furnace, but expect to put it into operation again in the course of six or eight weeks.

THE trustees of the late Dr. Ludwig Mond have paid over the sum of £66,500 in five per cent. war stock to the trustees of the endowment fund of the Davy-Faraday Research Laboratory of the Royal Institution.

MR. A. MUNRO, of Alloa, has taken over the business of MESSRS. Metcalfe, Duncan & Company, iron merchants, colliery furnishers, etc., 59, High Street, Dalkeith, and will continue it under the same style.

MESSRS. STEPHEN & SMITH, who are agents for the "Gilbert" wood split pulley, "Pioneer" pressed steel hangers, etc., have removed from Argyle Street to larger premises at 11 and 13, York Street, Glasgow.

THE SOLWAY IRONWORKS, at Maryport, belonging to the Workington Iron & Steel Company, Limited, which have been standing since January 12, were restarted on February 4, when both furnaces were again put into blast.

MESSRS. E. V. ARUNDALE, H. GREAVES AND W. GREAVES, general engineers, London Works, 166, Francis Street, Birmingham, trading under the style of the Francis Manufacturing Company, have dissolved partnership.

THE London offices of J. Hopkinson & Company, Limited, Britannia Works, Huddersfield, having been taken over by the Government, the company's address is now Hastings House, Norfolk Street, Strand, London, W.C.2.

THE partnership heretofore subsisting between MESSRS. W. Hartley and H. Cottrell, carrying on business as metal merchants, at 130, Burlington Street, Ashton-under-Lyne, under the style of W. Hartley & Company, has been dissolved.

A RUMOUR was current last month that negotiations were preceding for a working arrangement between Vickers, Limited, Wm. Beardmore & Company, Limited, and armament firms in the Midlands.

MR. J. MARSHALL, of Marshall, Sons & Company, Limited, Britannia Ironworks, Gainsborough, has, for the present, withdrawn his application to the Board of Trade for a Provisional Order for supplying electricity in Gainsborough for public and private purposes.

VICKERS, LIMITED, have acquired an interest in the business of Robert Boby, Limited, of Bury St. Edmunds and London. Sir Vincent Caillard and Sir Francis Barker, directors of Vickers, Limited, have been elected to the board of Robert Boby, Limited.

MESSRS. M. G. CARTER, B. Rosenbaum, and O. Steinberger, engineers, 9, Robert Street, Hampstead Road, London, N.W., and 23-25, Northdown Street, King's Cross, London, N., trading under the style of the Grecar Engineering Company, have dissolved partnership.

The Government—our Parliamentary correspondent states—have decided to re-introduce their Bill to amend the Trade Marks Act, 1905, and in the meantime the Association of Chambers of Commerce have appointed a special committee, including Sir Algernon Firth, Bart., the President, to consider its provisions.

TEMPORARY accommodation for the Sheffield Association of Metallurgists and Metallurgical Chemists has been found at the Royal Victoria Hotel. The opening meeting was held on Monday, February 4, when the president, Mr. W. H. Hatfield delivered an address dealing with the rules, aims and objects of the association.

IN the course of his Welsh tour this week the Prince of Wales has visited the Port Talbot Steelworks (under the guidance of Col. Charles Wright), the works of Curran's Metal and Munition Company, the Ebbw Vale Steel Works (under the guidance of Mr. F. Mills), the Cardiff-Dowlais Works, and the Victoria Pit at Ebbw Vale.

IN reply to COL. SIR A. HALL, last month, the HOME SECRETARY said that, after considering all the representations, he had decided that for the present year summer time should be brought into force on the morning of Sunday, March 24, and continue until the night of Sunday, September 29, an arrangement that would give an additional five weeks of summer time this year.

WE understand that an amalgamation arrangement has been arranged between Vickers, Limited, and the Contraflo Auxiliary Condenser Company, Limited (Richardsons, Westgarth & Company, Limited), which will enable the former company to manufacture and equip all ships built by them, both for the Royal Navy and the Mercantile Marine, with the Contraflo type of condenser.

MR. JOSEPH OXLEY has severed his connection with Thos. Oxley, Ltd., of Sheffield, of which company he was a director and manager, and also the founder of the iron, steel and machinery department. Mr. Oxley has commenced business at Vicar Lane, Sheffield, with depôts at Sheffield and works at Darnall (Great Central Railway) and Unstone (Midland Railway), as iron, steel, scrap and machinery merchant.

IN his presidential address to the Society of Engineers on February 11, Mr. W. B. Eason referred to the fact that sixty years ago shipbuilding and engine-building were great industries in the immediate vicinity of London. Ships of war, the finest ocean-going steamers, and the fastest sailing vessels were built on the Thames, including the first iron vessel owned by the British Government and the first armed ocean-going battleship.

IN the House of Commons, on January 30, SIR L. WORTHINGTON EVANS, in reply to Mr. Rupert Gwynne, said that he had already explained to his hon. friend the reasons for which it was considered inadvisable that the Ministry should take direct delivery of scrap iron. Brass and copper scrap from the Army and Navy which was required by the Ministry was taken over direct. Zinc scrap required to be re-melted before it could be used by the Ministry, and was allowed to be sold to the smelters for that purpose.

FOR private reasons, MESSRS. H. C. Siddens & Com-

pany, Exchange Buildings, Birmingham, have converted their business into a private limited liability company, under the style of H. C. Siddens & Company, Limited. The business has been amalgamated with that of the home and foreign departments for the sale of iron, steel, tinplates and metals of Hills, Menke & Company, Limited, lately acquired by Mr. Stanley Goode, who has joined the board as managing director of the joint concerns.

A GROUP of firms engaged in the principal industries of the Manchester district have offered to the Governing Body of the School of Technology the sum of £3,000, spread over a period of five years, towards the cost of establishing a new department of Industrial Management. The Manchester Education Committee have accepted this gift. It is proposed that a lecturer shall be appointed for this period of five years, to conduct research in the subject of industrial management, to organise a new department, to lecture to members of the University and to the public, and to assist industrial concerns in the solution of management problems.

THE BRITISH ALUMINIUM COMPANY, LIMITED, have applied to the Secretary for Scotland for a provisional order empowering them to construct a series of works across the river Spean, Inverness, for the purpose of developing water power, motive power, and generating electrical energy by utilising "the largest available water power in Great Britain." The works are a development of the powers granted to the Loch Leven Water and Electric Power Company in 1901, whose undertaking was transferred to the Aluminium Company in 1911. It is estimated that the cost of the works will be about £1,594,876, and that they will give approximately 60,000 horse power.

MR. THOMAS GREENSMITH, managing director of J. & G Wells, Limited, Eckington Collieries, is combining along with his present duties those of managing director to the adjoining Renishaw Ironworks Company, Limited, which latter has recently been formed to carry on the old-established ironworks at Renishaw, near Chesterfield. Two of the three furnaces have been put into commission on basic iron, and the third furnace is expected to be in working order in a few months' time, after being rebuilt on modern lines and heightened several feet. Cowper stoves and a turbo-blower are part of the modern equipment of this plant. Mr. G. A. Eastwood, J.P., of Chesterfield, is the chairman of the new company.

A PROCLAMATION dated February 8 has been issued making amendments to the list of prohibited exports. The following headings have been deleted :—(b) Tin, and alloys of tin not otherwise specifically prohibited; (c) tin, manufactures of (except hollow-ware, tinplates, and receptacles made from tinplates); (b) tin ore; (a) wire, iron, and articles wholly manufactured thereof; (a) wire rods, iron; (a) wire, steel, and articles wholly manufactured thereof; (a) wire rods, steel. The following headings have been added :—(a) Tin and alloys of tin; (b) tin, manufactures of (except hollow-ware, tin plates, and receptacles made from tinplates); (a) tin ore; (a) wire rods and wire of iron or steel and articles manufactured wholly of such wire rods or wire.

STEEL, PEECH & TOZER, LIMITED, of Sheffield and Rotherham, acquired some months ago the works of the Frodingham Steel and Iron Company, Limited, and subsequently amalgamated with the Workington Iron and Steel Company, Limited. The company have now purchased from the Steel Company of Scotland their interest in the Appleby Iron Company. The Steel Company of Scotland had a half interest in the Appleby Company, the other half being held by the Frodingham Company. The Appleby Iron Company produced pig-iron only, and have four blastfurnaces. When the Steel Company of Scotland acquired an interest in it some years ago the intention was to add the manufacture of steel by the basic open-hearth process, which has not yet been done.

In dealing with the recent 12½ per cent. bonus during the debate on supplementary Civil Service Estimates in the House of Commons last month, MR. KELLAWAY stated that the effect of the bonus on industrial conditions had been thoroughly sound. There were fewer strikes now than at any period during the war, and he claimed that the bonus was one of the causes of that state of affairs. The increases of production in the last half-year's output with the bonus operating part of the time have been as follows :—

Guns.—48 per cent.
Machine Guns.—20 per cent.
Aeroplanes.—42 per cent.
Aeroplane Engines.—68 per cent.
Shipbuilding Material.—25 per cent.

THE shareholders of William Cooper & Goode, Limited, have approved of the scheme to amalgamate the company with Elliott's Metal Company, Limited. Explaining the reason for the proposed transfer of the business at a meeting of the shareholders, Mr. T. W. Horton said that after the war he anticipated there would be very serious competition in the metal trade. At Bradford Street, where the works were situated, they were not advantageously placed for meeting strenuous competition because they had no canal or railway siding, and everything had to be carted to the works. On the other hand, Elliott's Metal Company, Limited, was a firm with great resources, and their works at Selly Oak had many of the advantages which Cooper & Goode's lacked.

WITH the exception of one particular portion which may be named the Bilston district, steel making in South Staffordshire upon any large scale has long stood still. Compared with other parts of the kingdom, this district as a steel maker has been peculiarly backward, a condition which has often been the occasion of invidious comparisons. With 1918, however, some important alterations will be carried out, and the change is one which will occasion great satisfaction over an extensive area. The new schemes are the more noteworthy since, although the enormous demands which are being made by the Admiralty and the War Office upon the steel resources of the entire kingdom may have furnished the immediate inspiration for them, a broader foundation has undoubtedly been deemed to exist in the demands which civil buyers, both home and export, have during the last few years been found to frequently express that Staffordshire would go more deeply into the steel trade than hitherto, at the same time promising ample orders. The most important extension is one resolved on by one of the oldest steel-making firms in the Black Country, namely, the Patent Shaft and Axletree Company, Limited, of Wednesbury, who are well known in connection with the railway wheel and axle industry, and as producers of constructional work. This firm have completed their plans for an increase of blastfurnace capacity and the laying down of new steel smelting and rolling mill plant at an estimated cost of some £250,000. The blastfurnace plant is to be devoted to basic iron. Hitherto the Patent Shaft Company have mainly rolled plates and sectional material needed in connection with their bridge-building and railway wheel and axle manufacture, and steel for railway carriage and wagon building, the circumstance that the firm are now amalgamated with the Metropolitan Railway Wagon and Finance Company, Limited, of Saltley, Birmingham, supplying important need for this last output.

Query.

A Small Steel Mixer.

A small converter steel foundry desires a separately fired mixer suitable for holding, say, ten tons of molten steel, in order to cast a single ten-ton casting occasionally from a two-ton converter. How can this requirement best be met?

"G. W. B."

Personal.

THE late Sir Wm. H. Lindley, the eminent civil engineer, left estate valued at £15,088.

SIR RALPH ANSTRUTHER, BART., has been elected a director of Mercy & Cuninghame, Limited.

THE late Mr. George Bell, retired engineer, of Carnoustie, has left estate to the value of £56,867.

MR. G. B. WATERHOUSE has been appointed consulting metallurgist to the Bureau of Mines at Washington, U.S.A.

THE RIGHT HON. SIR HENRY NORMAN, Bart., M.P., has been appointed an additional member of the Air Council.

SIR WILLIAM BEARDMORE has been awarded this year's Bessemer Gold Medal of the Iron and Steel Institute.

THE late Mr. W. Wood, of Burnbrae, Falkirk, a director of the Callendar Iron Company, Limited, left estate valued at £19,739.

MR C. T. CORLESS, manager of the Coniston Works of the Mond Nickel Company, Limited, has been elected a director of the company.

SIR WILLIAM ROWAN THOMSON, K.B.E., has resigned his position as the Director of Machinery to the Shipbuilding Advisory Council.

MR. M. L. SIMPSON, general works manager of the Steel Company of Scotland, Limited, has been elected a director of the company.

MR. A. H. GUNN has been elected chairman of Sir John Gunn & Company, Limited, in succession to his father, the late Sir John Gunn.

THE gross value of the estate of the late Mr. T. Dixon, secretary and director of Sir Raylton Dixon & Company, Limited, is £23,183.

THE late Mr. W. Blenkinsop, iron merchant, of Middlesbrough, left estate valued at £16,079 17s. 8d., with net personalty £9,177 9s. 8d.

PERSONAL estate of the value of £83,305 has been left by the late Mr. R. R. A. Dubs, of the North British Locomotive Company, Limited.

CAPTAIN ALGERNON W. HENEAGE has been gazetted a rear-admiral in the Royal Navy. He is a director of the firm of Vivian & Sons, Limited.

MR. J. W. BEATTIE, designing engineer to the Workington Iron & Steel Company, Limited, has been appointed chief engineer to the Blaenavon Company, Limited.

MR. F. B. JACK, of the Worthington Pump Company, Limited, has accepted a position at the Sheaf Works, Lincoln, of Ruston, Proctor & Company, Limited.

THE late Major F. Jones, of Larbert, Stirling, formerly managing director of Jones & Campbell, Limited, engineers, etc., has left estate to the value of £13,602.

MR. H. BROWN, of Horrington, assistant engineer to the Workington Iron & Steel Company, Limited, has been appointed engineer to the Stanton Ironworks Company, Limited.

THE estate of the late Mr. J. C. Merryweather, governing director of Merryweather & Son, Limited, fire engine makers, has been sworn at £135,975, with net personalty £131,980.

SEC.-LIEUT. A. R. LATCH (Tanks Corps), second son of the late Mr. Arthur Latch (Latch & Batchelar, Ltd., Birmingham), has been awarded the D.S.O. for conspicuous bravery whilst in command of his "Tank" in the Battle of Cambrai.

MR. C. H. WORDINGHAM, president of the Institution of Electrical Engineers, has been appointed to be the representative of the Institution on the Governing Body of the Imperial College of Science and Technology, in place of the late Mr. W. Duddell.

SIR WILLIAM WEIR has been appointed a member of the Munitions Council in charge of Aircraft Production, at the same time retaining his position on the Air Council. Sir Herbert Hambling has vacated the office of Member of Council in charge of Finance.

THE late Mr. R. Wright, mechanical engineer, of Newcastle, for half a century connected with the Elswick Works of Sir W. G. Armstrong, Whitworth & Company, Limited, left estate of the gross value of £27,774 19s. 9d., of which £20,958 5s. 8d. is net personalty.

ESTATE of the gross value of £425,843, of which £400,694 is net personalty, has been left by the late Mr. Isaac Butler, of Bryngomer, Griffithstown, near Newport, a director of Baldwins, Limited, and the Pyle & Blaina Works, Limited, and chairman of Cordes (Dos Works), Limited.

THE Premier has made the following additional appointments to the Committee on Production:—His Honour Judge Walworth Roberts (Chairman of Panels), Mr. James Garvin, J.P.; Judge Roberts and Mr. Garvin will also be members of the Special Arbitration Tribunal appointed by the Minister of Munitions to deal with questions arising out of the Orders granting a bonus to certain munition workers.

High-Speed Tool Steel.

We are informed that the maximum prices of high-speed tool steel have been advanced, the increase to date from February 1, 1918, the previous revision having taken place about two years ago.

The new maximum prices are now as follows:—

Finished bars, 14 per cent. tungsten ... 3s. 8d.
Finished bars, 18 per cent. tungsten ... 4s. 5d.
Per lb. delivered buyers' works.

All extras and conditions remain as hitherto.

Applications for Patents.

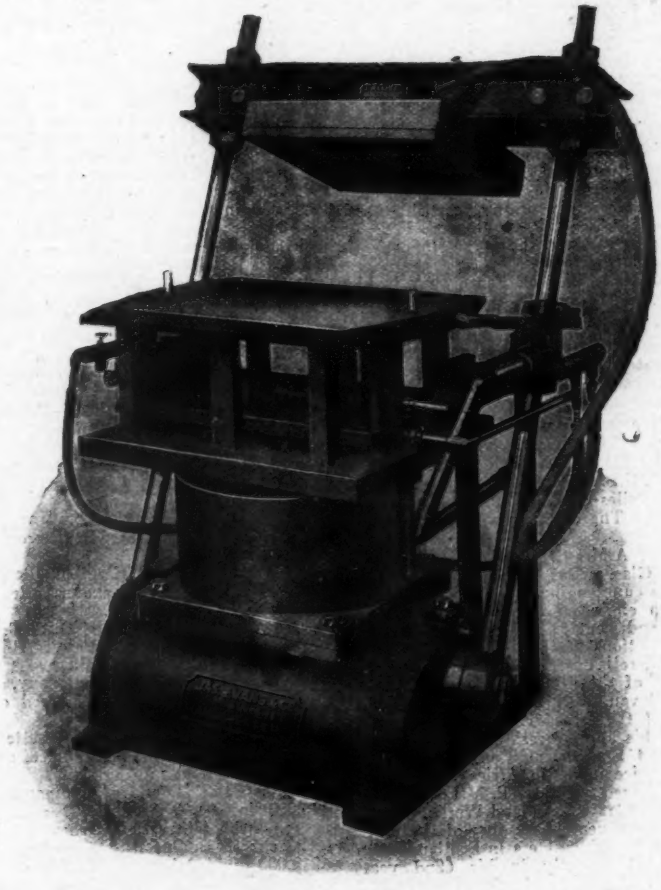
The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Armstrong, J. Metallurgy of zinc. 1,603. January 28.
Balfour, J. P. Treatment of graphitic, etc., refractory ores. 1,446. January 25.
Barfield, E. P., and Wild, L. W. Indicating condition of steel, iron, or other magnetisable metal during heat treatment. 1,905. February 1.
Bischoff, J. C., and Poppink, J. H. Apparatus for producing high temperatures for welding and cutting metals, etc. 1,561. January 26. (Holland, April 27, '17.)
Bosworth, A. W., and Elkington & Company. Muffles or metal-heating furnaces. 2,135. February 6.
Bowen, H. E. Steel-melting, etc., furnaces. 2,273. February 8.
British Carbonising Company, and Fennell, W. Carburisation of iron and steel articles, and material to be used in the carburising process. 2,007. February 4.
Carlson, O. F. S. Furnaces. 2,247. February 7.
Donald, W. Open-hearth, etc., metallurgical furnaces, etc. 1,229. January 22.
General Electric Company. Electric furnaces. 2,368. February 9.
Industrial Electric Furnace Company. Electric furnaces. 1,896. February 1.
Naish, W. A. Aluminium alloys. 2,186. February 6.
Norton Company. Aluminous abrasive. 2,252. February 7. (United States, February 12, '17.)
Norton Company. Composition containing alumina and zirconia. 2,253. February 7. (United States, February 12, '17.)
Norton Company. Aluminous abrasive, and method of preparing same. 2,254. February 7. (United States, February 12, '17.)
Norton Company. Products containing β-alumina, and processes of preparing same. 2,255. February 7. (United States, March 2, '17.)
Norton Company. Aluminous abrasives, and process of making same. 2,256. 2,257. February 7. (United States, August 2, '17.)
Robertson, D. Device to lessen oxidation when tapping steel from smelting furnace. 2,213. February 7.
Rouse, T. Manufacture of iron and steel. 1,557. January 26.
Smallwood, A. Furnaces. 1,925. February 2.
Steel, Peech, & Tozer. Steel-melting, etc., furnaces. 2,273. February 8.
Stokes, F. W. Casting machines. 1,112. 1,113. January 19.
Strettles, S. Foundry moulding. 2,302. February 8.
Thermalloy, Limited, and Vautin, C. Ignitable metallic mixtures. 1,003. January 17.
Wilbraham, E. C. B., and Coley, H. E. Manufacture of metallic alloys. 2,092. February 5.
Wood, D. H. and W. H. Foundry moulding boxes. 1,107. January 19.

MOULDING MACHINES

OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.



JAMES EVANS & CO., BRITANNIA WORKS,

BLACKFRIARS, **MANCHESTER.**

Deaths.

MR. P. T. CAMPBELL, consulting engineer, died suddenly on January 30 at "Elmcroft," 36, Muswell Avenue, London, N.

THE death is reported from Bournemouth of Mr. W. MacGregor, steel merchant and agent, of 93, Hope Street and Pollokshaws Road, Glasgow.

THE death took place on February 9, at Richmond, Surrey, of Mr. E. G. Rivers, late chief engineer of H.M. Office of Works, at the age of 68 years.

MR. C. WEBSTER, a well-known naval architect, died recently. He was for thirty-five years in the employment of Messrs. John I. Thornycroft & Company.

THE death occurred at Beechwood, Uddingston, on February 7, of Mr. W. Cuthill, formerly of the Steel Company of Scotland, Limited, at the age of 72 years.

THE death is announced of Mr. R. Kelly, general outside manager of the engine department of Alexander Stephen & Sons, Limited, shipbuilders, Linthouse, Glasgow.

MR. FINLAY ROSS, formerly manager of the Clyde Tube Works of Stewarts & Lloyds, Limited, has died at his residence, Balcray, Dunbeth Avenue, Coatbridge, at the age of 70.

ON February 4 the death occurred at Lincoln of Mr. Charles Hopewell, who had been connected with the engineering firm of Ruston, Proctor & Company, Limited, for over fifty years. He was 72 years of age.

MR. WM. MORISON, secretary of the Scottish Steel Makers' Association, the Scottish Employers' Federation of Iron and Steel Founders, the West of Scotland Iron and Steel Founders' Association, and the Ayrshire Founders' Association, died on February 5, in his 69th year.

MR. J. A. THOMPSON, a member of the firm of Messrs. J. L. Thompson & Sons, shipbuilders, North Sands, Sunderland, died on February 4. The deceased, who was 41 years of age, and had been in ill-health for some time, was the son of the late Mr. Robert Thompson, of Darlington.

THE death took place on January 26, at his residence, Hazel Lodge, Holland Villas Road, Kensington, W., of Mr. W. S. Accles, M.I.M.E., F.R.G.S., formerly of Hartford, Conn., U.S.A., and for 21 years European manager of the Niles-Bement-Pond Company, 25, Victoria Street, S.W. The deceased was 61 years of age.

MR. T. ANDERSON, A.M.I.C.E., who died recently at his residence in Glasgow at the age of 76 years, was well known as an engineer. He served his apprenticeship as an engineer with the Caledonian Railway Company, and went to India in 1864. After occupying various positions in the R.I.M. he in 1885 became chief engineer, retiring from the service in 1897.

MR. J. A. M'KIE, of the firm of Messrs. M'Kie & Baxter, engineers, Govan, died recently. Mr. M'Kie was the third son of the late Mr. James M'Kie, of Bargaly, and served his apprenticeship with the Fairfield Shipbuilding and Engineering Company, Govan. After a period of service in South Africa he returned to this country, and joined with Mr. P. M'Leod Baxter in the firm of M'Kie & Baxter, Copland Works, Govan. Mr. M'Kie was for many years a member of the Institution of Engineers and Shipbuilders in Scotland.

THE death occurred recently in his 62nd year of Mr. G. L. Clark, J.P., of Talygarn. Mr. Clark was one of the foremost public men in Glamorgan. His father, the late Mr. George Thomas Clark, was closely associated with the management of the Dowlais Ironworks. The deceased gentleman, with Lord Aberdare, acted as co-trustee for the Dowlais Ironworks for Lord Wimborne. He was also, and had for some years been, the chairman of the Rhymney Railway Company, and it was during his régime that the closer relations that now exist between the railway and the docks were brought about.

WE regret to announce the death of Mr. L. F. Gjers, J.P., which occurred at his residence, Busby Hall, Carlton-in-Cleveland. The deceased gentleman was the son of the late Mr. John Gjers, the founder of the Ayresome Ironworks, and the prosperity of the inheritance which he received from his father was maintained and advanced under his direction. The works under his control have been kept at a high state of efficiency, and this is probably due in no small measure to the close and friendly relations which have always existed between Mr. Gjers and the staff.

New Companies.

Tipton Foundry, Limited.—Capital £5,000 in £1 shares.

Priors' Aerial Patents, Limited.—Capital £50,000 in £1 shares.

Northumbria Motors, Limited.—Capital £25,000 in £1 shares.

Norwood Engineering Company, Limited.—Capital £20,000 in £1 shares.

Burton Hill Silica Company, Limited.—Capital £15,000 in £1 shares.

Weldon Engineering Company, Limited.—Capital £50,000 in £1 shares.

Nowell and Cox Engineering Company, Limited. — Capital £10,000 in £1 shares.

Bradley Tool Manufacturing Company, Limited.—Capital £5,000 in £1 shares (200 preference).

Ernest Johnson & Company, Limited. — Capital £20,000 in £10 shares, to carry on the business of shipbuilders.

Tilston Engines, Limited. — Capital £5,000 in £1 shares. Registered office: Albion House, 59-61, Oxford Street, W.C.

Smith & Ewen (Aeroparts), Limited.—Capital £5,000 in £1 shares. Registered office: 42, Frederick Street, Birmingham.

R. Robinson (Gresley), Limited.—Capital £10,000 in £1 shares, to carry on the business of fire-brick manufacturers, etc.

Berry's Electric, Limited.—Capital £50,000 in £1 shares, to carry on the business of electrical and general engineers, etc.

Canonbury Engineering Company, Limited.—Capital £4,000 in £1 shares. Registered office:—34, Northampton Street, Islington.

Whitehall Dockyard Company, Limited.—Capital £100,000 in £1 shares. Registered office:—1-3, Cree church Lane, E.C.3.

Alphaero Engines (Foreign Patents), Limited. — Capital £10,000 in £1 shares. Registered office: 57, Gracechurch Street, E.C.

Brown's Shipbuilding and Dock Company, Limited.—Capital £20,000 in £1 shares. Registered offices:—Lime Street, Kingston, Hull.

Kelvin Construction Company, Limited.—Capital £1,500 in £1 shares. Registered office: 315, North Woodside Road, Glasgow.

Walker Fender Company, Limited.—Capital £5,000 in £1 shares. Registered offices:—Despatch Works, Sherborne Street, Birmingham.

Atlas Brass Foundry Company, Limited.—Capital £6,000 in £1 shares (1,000 preference). Registered office:—Abbot Street, Gateshead.

Blackhall Engineering Company, Limited.—Capital £12,000 divided into 11,775 ordinary shares of £1 each and 9,000 deferred shares of 6d. each.

Cambrian Aircraft Constructors, Limited.—Capital £110,000 in 100,000 cumulative and participating shares of £1 and 200,000 ordinary shares of 1s. each.

J. M. Farnol, Limited.—Capital £1,000 in £1 shares, to carry on the business of die sinkers, stampers, etc. Registered office:—19, Hall Street, Birmingham.

Pryke & Palmer, Limited.—Capital £75,000 in £1 shares, to carry on the business of iron merchants Registered offices: 40-41, Upper Thames Street, E.C.

John Ackland & Company, Limited. — Capital £25,000 in £1 shares (10,000 7 per cent. cumulative preference), to carry on the business of metal merchants.

(*Continued on page* 164.)

THE NEW STEEL

COBALTCROM PATENT AIR HARDENING HIGH SPEED STEEL

(British Patent No. 106187).

THIS Steel is now in regular use in more than one thousand works in Great Britain, and its efficiency as a first-class utility High-speed Steel is firmly established.

The hardening of Cobaltcrom Steel by the new method introduced this year is simpler, surer, and less risky than that of any known High-speed or High-duty Alloy Tool Steel, and practically dispenses with all skill hitherto regarded as indispensable for hardening High-grade Tools.

The adoption of Cobaltcrom Steel results in considerable saving of labour and marked increase in armament, motor, aircraft and shipbuilding production; in fact, beneficially affects every industry where steel tools are used.

It is the ideal universal tool steel for general maintenance in machine and repair shops of all classes of industry, as tools, by slight variation in the heat treatment, can be made either shock-resisting or extra hard.

Tool room problems which have been regarded as impracticable have been solved by the adoption of Cobaltcrom Steel in bars, sheets, and in particular, Form castings.

Send your Manager, Foreman, or Tool Room Superintendent to Sheffield to see our exhibition of milling cutter and other castings in "The New Steel."

MANUFACTURED UNDER LICENCE BY

DARWIN & MILNER, Ltd., SHEFFIELD. | **SYBRY, SEARLS & CO., Ltd., SHEFFIELD.**

Manufactured under licence in the United States of America by the Latrobe Electric Steel Co., Latrobe, Pa., and Darwin & Milner, Inc., New York.

Fortluminium, Limited.—Capital £10,000 in 9,500 £1 ordinary and 10,000 1s. deferred, to establish and develop the aluminium alloy known as Fortluminium, etc.

Knox Manufacturing Company, Limited.—Capital £2,000 in £1 shares, to carry on the business of mechanical, chemical, electrical, and general engineers, etc.

Abbey Works, Limited. — Capital £10,000 in £1 shares to carry on the business of engineers. Registered office: 5, Albany Court Road, Piccadilly, London, W.

Commercial Waste Recovery, Limited. — Capital £50,000 in 45,000 shares of £1 each, and 100,000 shares of 1s. each. Registered office: 14, Waterloo Place, S.W.

Jackson Brothers (Hyde), Limited.—Capital £5,000 in £1 shares, to take over the business carried on by Jackson Brothers, at Spring Fields Ironworks, Newton, Hyde, Cheshire.

Queenborough Shipbuilding Company, Limited. — Capital £25,000 in £1 shares (10,000 participating preferred). Registered office:—Moorgate Station Chambers, London, E.C.

Vulcan Iron & Metal Works (1918), Limited.—Capital £30.000 in £1 shares, to take over the existing company. Registered office:—4, Great Marlborough Street, London, W.

Birmingham Die Casting Company, Limited.—Capital £4,005 in 100 "A" shares of 1s. each, and 4,000 ordinary shares of £1 each. Registered office:—20, Copthall Avenue, E.C.

Robert Hall Engineering Company, Limited.—Capital £5,000 in £1 shares (1,000 7 per cent. cumulative preference). Registered office:—67, Long Lane, W. Smithfield, London, E.C.1.

Malden Engineering & Aircraft Equipment Company, Limited.—Capital £3,000 in £1 shares (2,900 7½ per cent. cumulative preference). Registered office:—College Works, Malden Road, New Malden, Surrey.

Samuel Groves & Company, Limited.—Capital £30,000 in £1 shares, to take over the business carried on by H. Groves, as Samuel Groves, at Musgrave Road, Soho, Birmingham, as pressers of metal wares, etc.

Witchell & Company, Limited.—Capital £5,000 in £1 shares, to take over the business of engineers and metal workers carried on by E. J. & A. P. Witchell at the Endwell Engineering and Metal Works, Brockley, as Witchell & Company.

C. and J. Svedberg (London), Limited. — Capital £5,000, in £100 shares, to take over the business of iron, steel, and general merchants carried on in London by C. Svedberg and J. Svedberg, as C. and J. Svedberg. Sole governing director, C. Svedberg.

George Johnson & Company (Birmingham), Limited.—Capital £40,000 in £1 shares, to take over the business of metal rollers carried on by E. P. Gem and G. E. W. Johnson, as George Johnson & Company at Montgomery Street Rolling Mills, Birmingham.

Nicholson Brothers, Limited.—Capital £10,000 in £1 shares, to take over the business of general, motor and marine engineers and repairers carried on at Great Grimsby and elsewhere by Nicholson Brothers. Registered office:—Nibromo Engineering Works, Roberts Street, Grimsby.

Thomas Turner & Company (Sheffield), Limited.—Capital £50,000 in £1 shares, to take over the business of steel, cutlery, and plate manufacturers carried on by Thomas Turner & Company, and Wingfield, Rowbotham & Company, at Suffolk Works, Sheffield. Joint governing directors: A. J. Hobson and W. Hobson.

William Denny & Brothers, Limited. — Capital £500,000 divided into 250.000 6 per cent. cumulative preference and 250,000 ordinary shares of £1 each, to acquire the existing business of Wm. Denny & Brothers, shipbuilders, and Denny & Company, engineers, both at Dumbarton. Registered office: Leven Shipyard, Dumbarton.

The Mastery SIROCCO of the Air.

TRADE SIROCCO MARK

FANS

SEND US YOUR ENQUIRIES FOR

are always successful in the struggle for the Mastery of the Air

Ventilation of Ships, Buildings and Mines, Induced Draught on Boilers, Dust Removal, High Pressure Fans for Forge Fires and Cupolas, Air Washers for Cooling and Purifying the Air, Fans for Removing Fumes or Steam, Steam Heater Units for Heating Factories and Workshops.

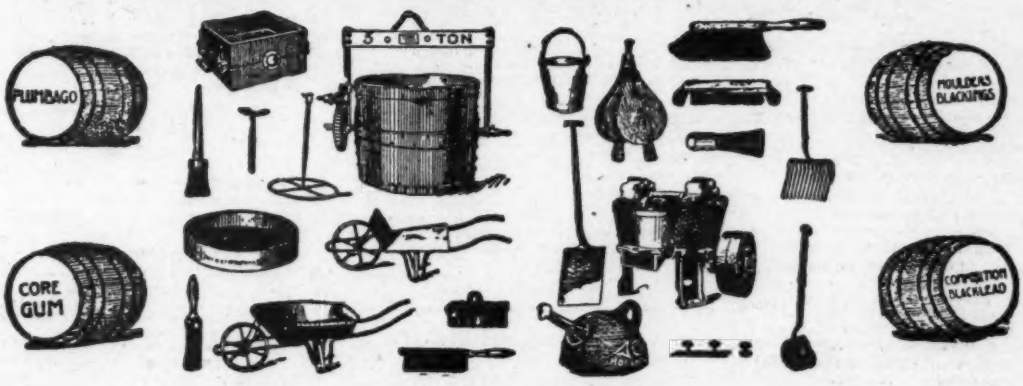
Davidson & Co., Limited, *Sirocco Works,* BELFAST.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



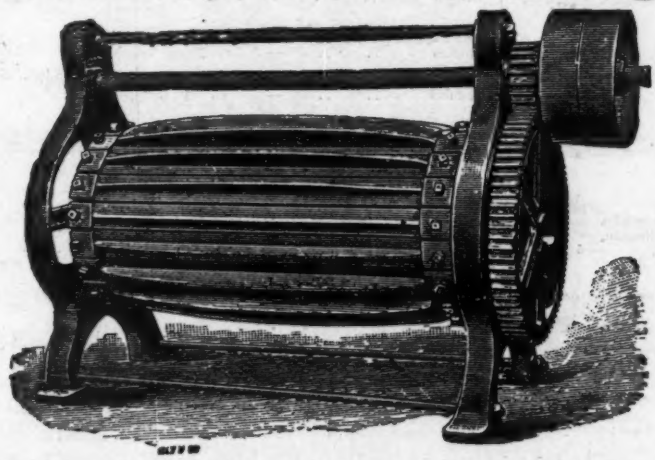
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour

The following testimonial explains itself:—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
HEMATITE—MALLEABLE—			
Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	17	6
Cleveland, No. 1	4	19	0
„ other grades	4	15	0
„ basic	5	0	0
Northamptonshire, forge	4	7	6
„ fdy numbers	89/0		94/0
„ basic	4	17	6
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	5	0	0
„ foundry	5	2	6
Common Staffordshire ..	4	15	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 2, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works.

Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 2s. 10d.

Finished bars, 18% Tung. 3s. 10d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings .. .. 5d.

Bar Ends .. .. 6d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	26	10	0
„ export	—		

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	..110	0	0	110	10	0
Three months	..110	0	0	110	10	0
Electrolytic ..	..125	0	0	121	0	0
Tough ..	..123	0	0	119	0	0
Best selected ..	..123	0	0	119	0	0

Tin.

Standard, Cash	..318	10	0	319	0	0
„ Three months	315	10	0	316	0	0
English Ingots ..				324	0	0
Bars	—			325	0	0
Refined	—			—		

Spelter.

American	54	0	0	50	0	0
Specials..	—			—		
Hard	46	0	0		0	0
British	56	10	0	57	0	0

Lead.

Soft Foreign (net)	.. 29	10	0	28	10	0
English	—			Nom.		

Antimony.

Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton	—			—		

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots..	—
CASTINGS.	Per lb.
I. or II.	—
III. IV. o V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. £50 above price of best selected copper.

15 per cent. Phosphor Copper .. £70 above price B.S.

Phosphor Tin (5 per cent.) .. £30 above price of English Ingots.

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM).

*Chromium (Metallic). 98/99% purity, per lb.	—		
*Nickel. In cubes, 98/99% purity Per ton	—		

Nickel Silver.

	per lb.
Ingots for raising	—
Ingots for Spoons and Forks ..	—
„ rolled to spoon size ..	—

Tungsten Metal Powder.

98/98% purity.. per lb. ..	—

Molybdenum Metal.

98/98% purity.. per lb. ..	—

Cobalt Metal.

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting..	—		—	
Iron scrap cast (cupola metal)	—		—	

London (f.o.b.).

Heavy steel	105	0	
Light „	55	0	
Heavy cast	95	0	

Control Prices.

Heavy Steel Melting Scrap	105	0	125	0
Steel Planings, Turnings and Borings	65	0		
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.	50	0		
Steel Scrap, all other Classes ..	95	0		
Wrought Iron Scrap	—		125	0
Ditto, mixed with Steel	95	0		
W.I. Planings, Turnings and Borings mixed with Steel, &c.	50	0		

Per ton delivered Buyers' Works.

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations:—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	—		
Hy. Selected Scrap Brass ..	—		
Hy. Tinned Copper Wire	—		
Best Selected Gunmetal Scrap ..	—		
Re-melted Ingot Lead	—		

Stocks.

Metals.

	Tons.
Copper, Europe and afloat	—
Tin London, Holland, U.S.A. and afloat	19,528

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	37	6	—	
Foundry	45	0	—	

Glasgow.

Foundry Coke	—		45	0
Furnace Coke	35	0	—	
Gas Coke	—			

London.

Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stations	44	0	46	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6		

CONTROL PRICES OF COKE.

	s	d.
Durham and Northumberland blast furnace	33	0
„ foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs., & Midland Counties blast furnace	32	0
South Wales blast furnace ..	37	6
„ foundry	50	0

All per ton net. f.o.t. ovens.

Cumberland blast furnace	37	0

d/d West Coast furnaces

SITUATIONS VACANT AND WANTED.

MOULDERS (6) and CORE MAKERS (2) wanted in Brass Foundry, London.—Apply to Box 918, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN ASSISTANT required for Machine Moulding Foundry. Permanent position and good prospects for suitable man. No person already on Government work will be engaged.—Apply, stating age, experience, and wages required to your nearest Employment Exchange, quoting No. A4700.

FOUNDRY FOREMAN, for large aluminium foundry on aircraft castings. Government work. Must be good organiser and big output man. Thorough knowledge of moulding machines essential. American experience desirable. Good salary and commission to right man. No one on Government work need apply.—Apply in writing, stating age, qualifications, salary required, to your nearest Employment Exchange, quoting No. A.4660.

STEEL METALLURGIST, expert in the manufacture of Special Alloy Steel and Castings by the Electric Process, desires position; excellent testimonials.—Address, "Z. T. 958," DEACON'S, Leadenhall Street, London.

PATTERNMAKERS wanted at once in large Aircraft Factory in London. Only men used to highest class motor and aeroplane engine work need apply.—State age, wages and experience to Box 932, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2. No one engaged on Government work or living more than ten miles away need apply.

ARCHITECT required, with varied experience in planning and supervising erection of extensive foundry plant for the manufacture of large and small light hollow castings in japan and porcelain enamel finish.—Address, Box 938, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

SITUATIONS VACANT AND WANTED (*continued*).

IRONFOUNDERS.—Qualified CHEMIST, with well-equipped private laboratory, is open to receive samples of Iron, Steel, Fuels, &c., for analysis. Accuracy and promptness guaranteed.—Apply, Box 942, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

WANTED, a competent FOREMAN for small Foundry engaged on Marine Engine Castings. Government controlled firm.—Apply, giving particulars to your nearest Employment Exchange, mentioning No. A4663. No person already on Government work will be engaged.

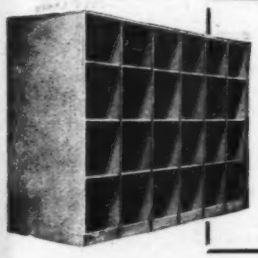
STEEL Foundry Furnace MANAGER and CHEMIST, wide experience in melting and finishing highest quality steels for castings and forgings, to meet existing specifications and tests, by Converter, Siemens and Electric Furnace processes, open for engagement; over military age.—Address, Box 940, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

PATTERNMAKER, 30, discharged from army, seeks change. Good all-round knowledge of light casting and general engineering trade; London or provinces.—Address, Box 934, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOREMAN MOULDER, good all-round experience, desires change. Iron, brass, aluminium.—Address, Box 936, Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

FOR SALE AND WANTED.

BRITISH PATENT No. 108,426, of 1916, relates to a drop flask Moulding Machine, whereby the system of moulding is rapid, accurate and inexpensive. Sale or licence.—TURNER, 28, Plumper's Road, Sheffield.



SANKEY

Fireproof Steel Storage Bins.
Clothes Lockers. Tool Chests.

Write for details.

JOSEPH SANKEY & SONS, LTD.,
Hadley Castle Works, WELLINGTON, Shropshire.

THE "PORTWAY"

PORTABLE CORE OVENS

For Gas or Fuel.

TESTIMONIAL.

From The Braintree Castings Co.,
Chapel Hill Foundries, Braintree, Essex.

Gentlemen,

We are very pleased with the Core Oven we recently purchased from you. We find it dries the cores quickly without burning them. It is very handy and economical to use and is altogether superior to other ovens of this type we have in use.

Will you please quote us your best price for four more like it,

Yours faithfully,
For The Braintree Castings Co.,
(Signed) W. B. LAKE, Director.

Makers: **C. PORTWAY & SON,** TORTOISE STOVE & PORTWAY PORTABLE OVEN WORKS, **HALSTEAD, ESSEX.**

JUST OFF THE PRESS.

NEW BRITANNIA CATALOGUE OF

MOULDING MACHINES,
CORE OVENS,
SAND MIXERS,
ETC., ETC., ETC.

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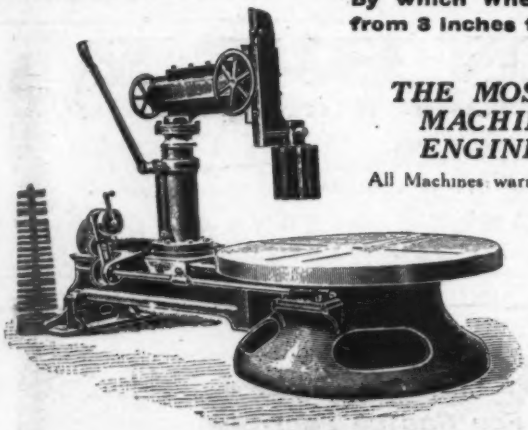
BRITANNIA FOUNDRY Co.
(A. P. SMITH, Proprietor),
COX STREET,
COVENTRY.

Government Controlled Establishment.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

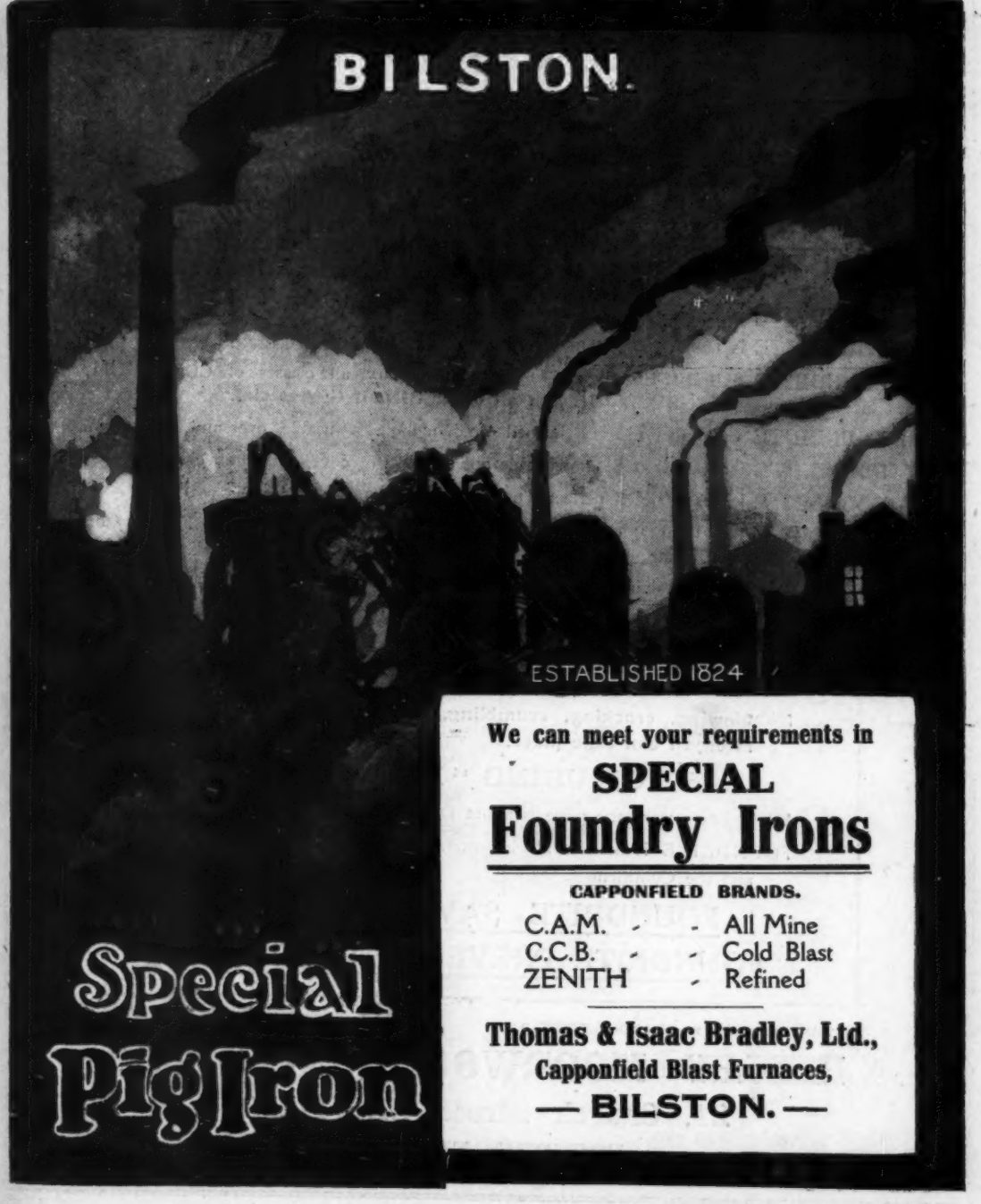
Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, *OLDHAM.*

CAPPONFIELD



Special Pig Iron

We can meet your requirements in

SPECIAL

Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
C.C.B.	Cold Blast
ZENITH	Refined

Thomas & Isaac Bradley, Ltd.,
Capponfield Blast Furnaces,
— BILSTON. —

"FOUNDRITE."

"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is **the** binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

FOUNDRITE SAVES MONEY.

FOUNDRITE PREVENTS WASTERS.

Telegraphic Address—"MOROD, SHEFFIELD." **Telephone 4318.**

HEDLEY MOORWOOD & Co., Ltd.,

21, Church Street, SHEFFIELD.

FOUNDRY EXPERTS.

FOUNDRY CUPOLAS, LADLES,

And the

OSBORN'S PATENT CUPOLA

SPARK ARRESTER

Are the Specialities of

T. DAVIES & SON,

RAILWAY WORKS,

WEST GORTON, MANCHESTER.

ON ADMIRALTY LIST.

Telegrams—"TUYERE, MANCHESTER." Nat. Telephone—No. 70, OPENSHAW.

CONTRACTORS to BRITISH and ALLIED GOVERNMENTS.

THE CONSTRUCTIONAL ENGINEERING CO.,

(Proprietors: STEEL WORKERS, LTD.)

Telegrams: "Structural, B'ham. Telephone: Midland 2182.

From Photo of No. 4 Cupola complete with Tank-form Spark Arrester.
Made in all sizes from ¼ ton melting capacity to 15 tons per hour.

Manufacturers of every description of Foundry Plant.

Largest Makers of CUPOLAS in the Midlands.

IMPROVED
Rapid-melting
Full-economising
CUPOLAS.

FOUNDRY LADLES
from 28 lbs. capacity
to 10 tons ,,
A large number usually in stock.

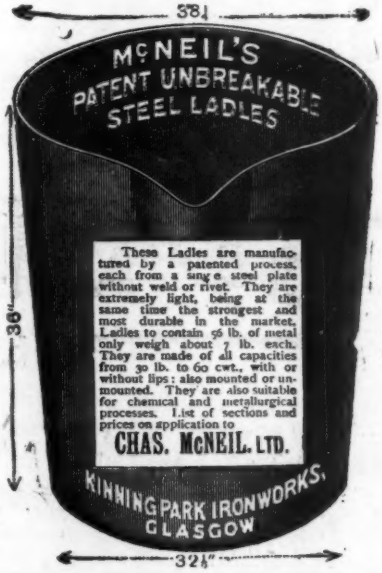
EMERGENCY CUPOLETTES.

Also Makers of
Charging Platforms,
Shaking Barrels,
Hoists, Cranes,
Runways, etc.

TITAN WORKS,
CHARLES HENRY STREET, BIRMINGHAM.

PLUMBAGO. GLUTRIN.
Parting Powder.
WILLIAM OLSEN, LTD.,
Cogan Street, HULL.
Wax Core Vent.
FOUNDRY MATERIALS AND REQUISITES.
WIRE BRUSH MANUFACTURERS.
STRAW ROPES.
CORE OIL. CORE GUM.

FIRE BRICKS & CLAY
CUPOLA BRICKS.
Best Quality.
LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.
KING BROTHERS,
(STOURBRIDGE) Ltd.,
STOURBRIDGE.


38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering

JOHN HALL & CO.

OF STOURBRIDGE, LIMITED.

STOURBRIDGE, ENGLAND.

Manufacturers of

FIRE BRICKS, BLAST FURNACE BRICKS AND CUPOLA BRICKS.

CUPOLA BRICKS

FOR LINING ORDINARY AND PATENT CUPOLA FURNACES.

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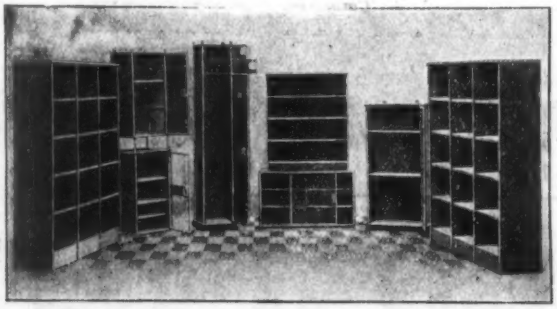

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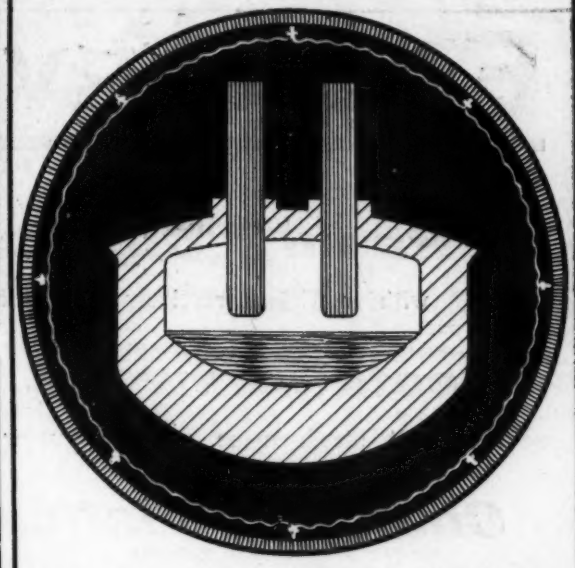

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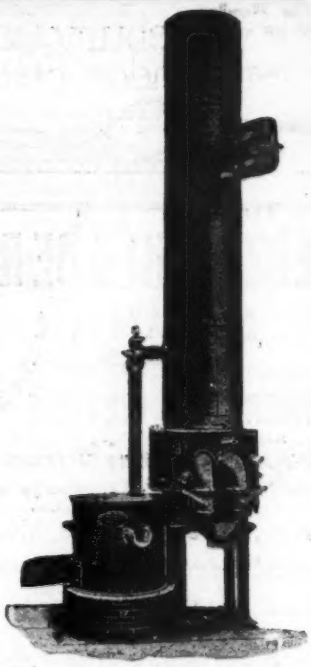

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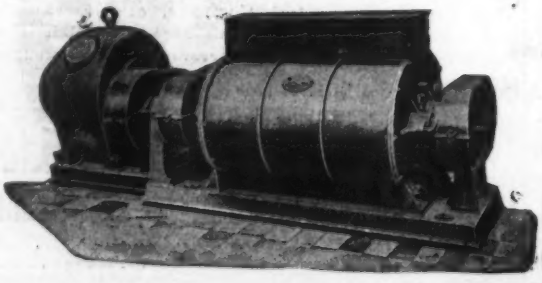

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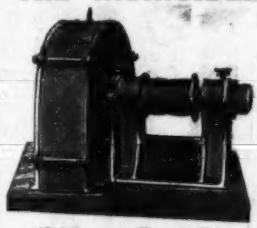

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